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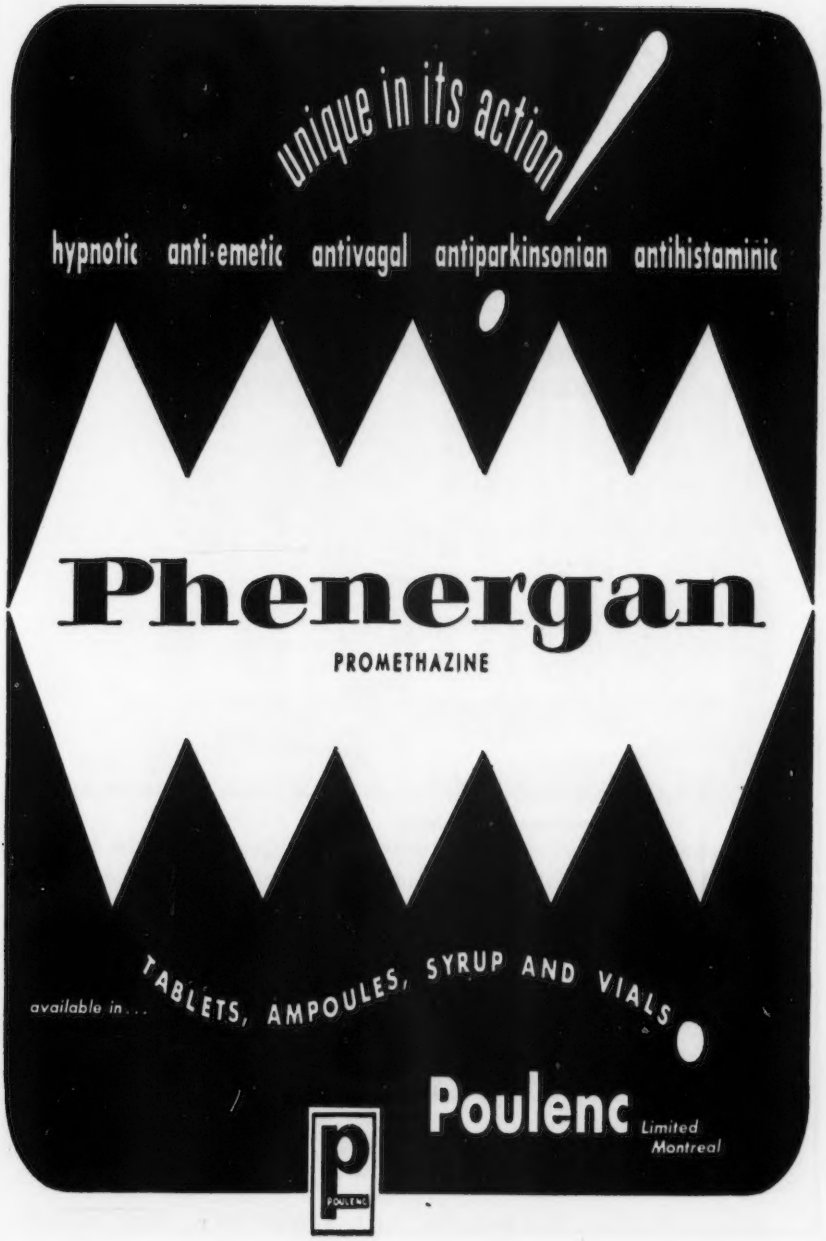
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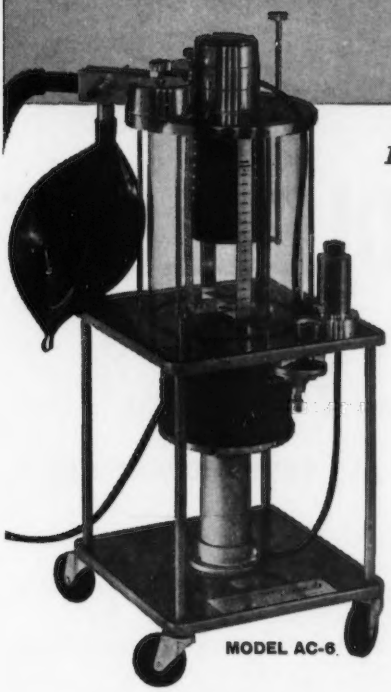

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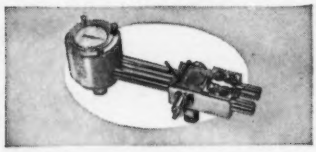

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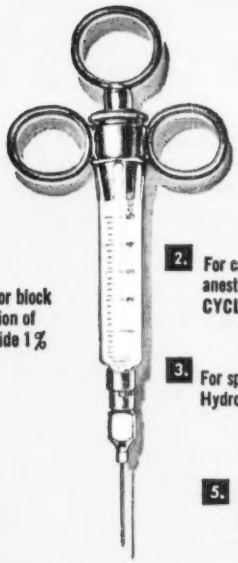

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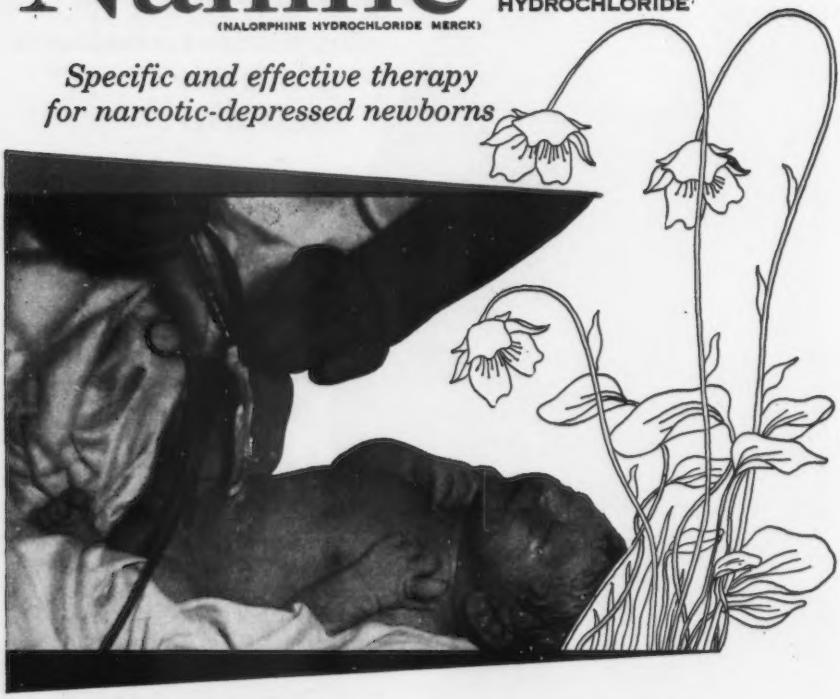

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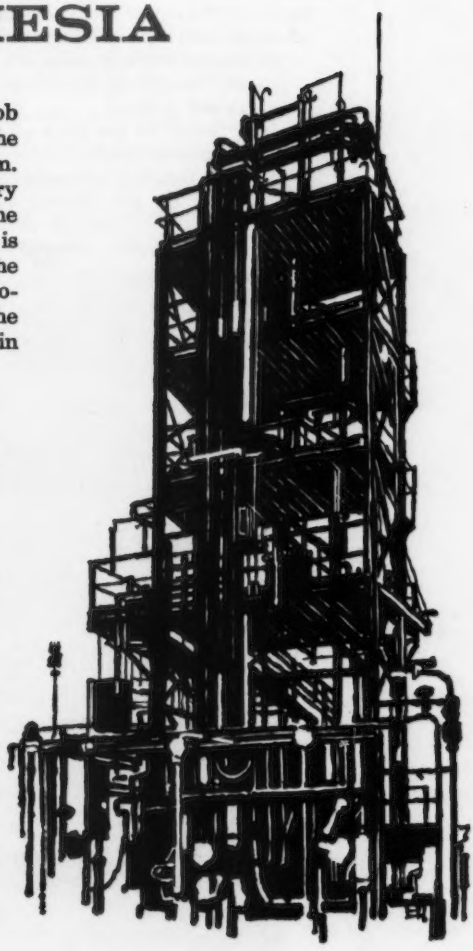

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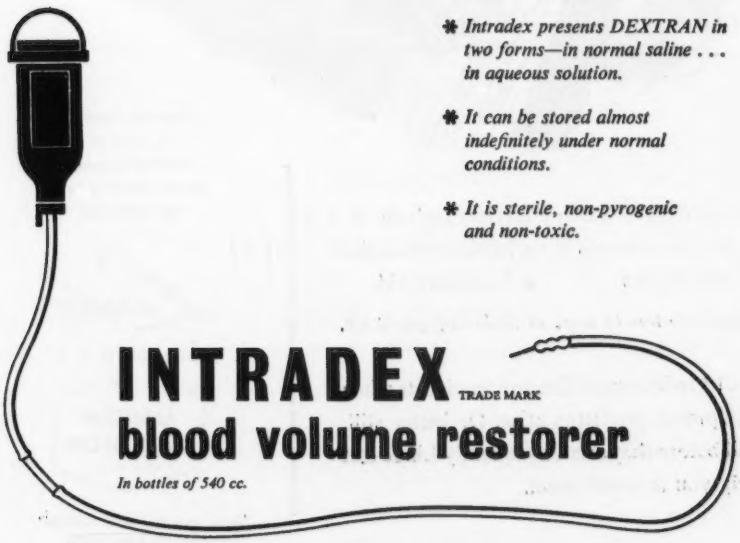

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THE LEGAL RELATIONSHIP BETWEEN THE SURGEON AND THE ANAESTHETIST[1]

JOHN H. HARLAND, M.B., B.CH.,[2] and ALAN W. MEWETT, LL.B., B.C.L., LL.M., S.J.D.[3]

THE RELATIONSHIP existing between the surgeon or the anaesthetist and the patient is fairly well defined from the legal point of view. This is well described in several sources readily available (1–6).

In a leading paper on the medico-legal aspects of anaesthesia (7), it is stated: "Prior to 1942, when a precedent was set in Ontario, the surgeon was considered to have full charge in the operating room, which included the anaesthesia. *The legal master-servant relationship existed between the surgeon and anaesthetist.*" (Italics supplied.) The italicized sentence indicates that the surgeon had vicarious responsibility for the actions of the anaesthetist. We doubt that this statement is a correct interpretation of Ontario Law, prior to 1942, but it represents the point of view of a person whose views must be listened to with respect, and a concept which would be readily approved of by many other authorities. It forms, in any event, a starting point in studying this interrelationship.

DIRECT RESPONSIBILITY TO THE PATIENT

The same legal principles apply to the relationship of the surgeon and the patient, the anaesthetist and the patient, and the patient and any person who undertakes to look after a patient, and actually does so. They may not have to undertake the task, but once having done so, they owe a duty of care to bring to the task the requisite skill and knowledge, and to perform it with a fair and reasonable standard of care and competence (1).

The relationship is only established when there has been a true assumption of responsibility, but once this exists, a duty of care is created. It must be remembered that this duty is just as valid where the services are rendered gratuitously, as where they are carried out for reward. The relationship may arise from a written contract, but more often arises independently of an express written contract.

Thus, it can be said that surgeon and anaesthetist both develop, independently of one another, a *direct* responsibility to the patient. If one person owes a direct duty of care towards another, he cannot escape his own responsibility by delegating this duty, or any part of it, to another person, no matter how competent the latter may be. As Lord Justice Denning put it: "When a person is himself under a duty to use care, he cannot get rid of his responsibility by

[1]Originally presented at the meeting of the Western Division of the Canadian Anaesthetists' Society, March 19–21, 1959, Saskatoon.

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delegating the performance of it to someone else. . . . to a servant under a contract of service, or to an independent contractor under a contract for services" (8).

Vicarious Responsibility to the Patient

The doctor's responsibilities do not end with what he does with his own hands. He can be held liable for the negligent acts of his subordinates, provided he has the right to control the manner in which they carry out their duties. This is the doctrine of *respondeat superior*. The subordinate in such a case is called a "servant," in the legal sense, and the adjective "vicarious" applies to this *indirect* liability of the principal. "It is also important to remember . . . that the principle of *respondeat superior* is not ousted by the fact that a "servant" has to do work of a skilful or technical character, for which the servant has special qualifications" (Lord Justice Somervell) (8).

The master may be liable even where he would lack the skill to do the servant's task himself. As put by Denning: "The reason why the employers are liable in such cases is not because they can control the way the work is done—they often have not sufficient knowledge to do so—but because they employ staff and have chosen them for the task, and have in their hands the ultimate sanction for good conduct—the power of dismissal" (8).

It must be remembered that, although the subordinate has a legal master, this does not free the servant of his own direct duty to the patient, or from his own liability for any breach of that duty. Indirect duty arises independently of direct duty and one person may owe to another both types of duty concurrently. The distinction between direct and vicarious responsibility is an important one and crucial to the subject under discussion.

Two Doctors with a Common Patient

Two physicians with one patient can be related in a number of ways. First, they may be independent and co-equal, neither being responsible for the negligent acts of the other, in which case they might be referred to as "persons with a common purpose." Second, if it happens that they are business partners, each is jointly and severally liable for the negligent acts of the other. Third, if one is able to control the manner in which the other does his work, for example, a salaried assistant, the subordinate is the legal servant of the other. Fourth, one may be subordinate to the other, but not his legal servant. He is then termed an "independent contractor."

The Master–Servant Relationship

The principle of *respondeat superior* means that the master is *vicariously* liable for the negligent act of his servant. He is not liable for the negligent act of his independent contractor unless he has delegated his own *direct* duty to such an independent contractor.

The distinction between servant and independent contractor is not absolutely

clear cut, but for our purpose it may be said that the independent contractor can be told what to do, but not how to do it; the servant can be given orders regarding both. The difference lies in the *right of control* of the master over the servant's actions. Failure to exert right of control does not relieve the master of vicarious responsibility.

The servant or the independent contractor is not ordinarily responsible for negligent acts of the master, but under certain circumstances his duty as a reasonable man might require him to draw attention to an error of the principal.

It was stated, in the paper quoted in the introduction, that the master–servant relationship existed in the general case of surgeon and anaesthetist, prior to 1942, in Ontario. In reality, however, the existence of such a relationship would have depended entirely upon the facts of each case coming to trial.

It will be seen as we proceed that the law in American jurisdictions, as it relates to master and servant, is at variance with Canadian concepts, in minor regards. In several states, the doctrine of the "borrowed servant" is applied. This is a discarded principle of British law in the area we are considering (8, 9, 10). In at least one state, "if the master in fact derives no profit from the employment of the servant, he is not liable for the servant's torts. On this reasoning, charitable institutions, such as hospitals, have been exempted from the ordinary rule of master and servant liability" (11, 12).

The Concept of Negligence

It is not intended to examine the legal concept of negligence in any detail in this paper. It must be remembered that it does not merely mean carelessness, but "connotes the complex of duty, breach and damage thereby suffered, by the person to whom the duty was owing" (1). For our purposes, negligence may be regarded as a breach of duty owed by one person to another, with resulting damage to the latter.

Anyone who undertakes a task, such as a surgeon performing an operation, or an anaesthetist[4] administering an anaesthetic, also undertakes to perform the task in a reasonably diligent and careful way. What is "reasonably careful" depends entirely upon the factual circumstances of the individual case. Among the factors which the court will take into account, we may mention the delicacy of the task, the general standards of knowledge among the profession, the fitness of the individual to undertake that particular task, and so on. The question is usually put in some such way as: "would the ordinary man, in view of the circumstances, say that the defendant had acted in a reasonable and careful manner." Failure to perform the task with the requisite standard of care is a breach of duty towards the plaintiff, and if damage results from that breach, the tort of negligence will have been committed. (For discussions of the nature of negligence, see the following references, 1, 2, 3, 4, 5, 6.)

[4]The word "anaesthetist" is used throughout to indicate a physician anaesthetist. This is the preferred practice in Canada, as in Great Britain. Where the word occurs in judgments, it is spelled as it appears in the original. The term "anesthetist" implies "nurse anesthetist"; in the United States, where the preferred term for a physician anaesthetist is "anesthesiologist."

It is perhaps worth mentioning that it will not necessarily be a valid defence to plead that one had done some procedure in a certain way, and that previously no harm had come of using that particular technique. "Neglect of duty does not cease by repetition to be neglect of duty," as Lord Tomlin put it (1), or as phrased by Justice Doyle: "Methods employed in any trade, business or profession, however long continued, cannot avail to establish as safe in law, that which is dangerous in fact" (13).

In a few of the cases, which will be cited, the plaintiff has based his action upon a technical assault, that is a trespass upon his person. Any intentional touching of a person, without his consent, constitutes an assault. The plaintiff must show that the acts of the defendant went beyond the consent which the plaintiff gives for the touching necessary for the due performance of the operation. This may be difficult for the plaintiff to prove, but it does have the advantage of relieving the plaintiff of the burden of proving lack of reasonable care which is necessary in an action in negligence.

Precedent

Every case tried could be said to form a precedent. However, the points of law brought out are mostly repetitive and in the average situation there will be a few leading cases which are referred to as authority. Common law is based on precedent. A decision of a superior court on a point of law, once made, remains binding on any lower court, and in some cases upon that court or a court of equal jurisdiction.

In Canada, this principle operates only within the judicial system of the province, unless the case is appealed to the Supreme Court of Canada. Relevant decisions in other provinces and Great Britain, particularly where the matter concerns some point of law never previously decided, are merely highly persuasive. Decisions from other jurisdictions, such as other parts of the Commonwealth or the United States, are persuasive to a lesser degree.

It is often a matter of annoyance to the physician that when he asks his legal adviser as to the best manner to act in a particular situation, he does not receive a clear-cut answer. In regard to this it must be remembered that " 'The Law' is not a body of systematised rules, enacted as a whole and fixed for all time. Judges have always exercised the power of developing the law, and this is now recognized to be a proper part of their function" (14). Thus the lawyer can only proffer *advice*. He cannot guarantee that following this advice will ensure against an action.

The Practicality of Redress

When several people are looking after a patient, he may be injured by the negligent act of one of them. When the patient has been rendered unconscious, it may afterwards be impossible for the plaintiff to say exactly which of the defendants was actually responsible.

This sort of group situation offers considerable difficulty in malpractice trials. For a discussion of the applicability of the doctrine of *res ipsa loquitur* and the principle of absolute liability, see references 1, 3, 15, and 16.

The leaning of Canadian and British law is towards the idea that because an accident happens and damage is thereby sustained, this alone does not mean that *someone* must pay for it. As put by Lord Justice Scott, "The standard of care which the law requires is not insurance against accidental slips. . . . It is not every slip or mistake, which imports negligence" (17).

On the other hand, in at least two American decisions, the view seems to have been taken that since damage had been sustained the injured party should be able to recover, and with that in mind it was ruled that the operating surgeons were responsible for the negligent acts of those working under them (16, 18).

The law is not anxious that a state of affairs shall arise where the only remedy the injured person has is against an impecunious person from whom adequate recovery would be impossible. In some states, state-operated institutions cannot be sued. Such protection is called "sovereign immunity," since it is based historically on the concept that "the King can do no wrong." In some jurisdictions, "non-profit" charitable institutions enjoy similar privileges (11). In such jurisdictions, there may be a tendency to find the operating surgeon liable for the negligence of a hospital employee, whose general legal master, the hospital, enjoys immunity.

The Anaesthetist as Legal Servant of the Surgeon

The idea of the anaesthetist as the surgeon's legal servant could have arisen because of some general and some specific legal reasons. Among the general reasons, one might include the following points.

1. The anaesthetist is historically a newcomer in the domain of surgery, and he owes his existence as a specialist to the increasing complexity of modern surgery and anaesthesia.

2. The patient has most usually sought out the surgeon himself or has been referred to him by another practitioner—by virtue of the reputation enjoyed by that surgeon. Only under exceptional circumstances will the patient specify or engage a particular anaesthetist on his own initiative. The only persons who take an active interest in this are doctors and their families.

3. The patient is primarily submitting himself to operation for benefit expected from the surgical procedure. The anaesthetic is therefore only a secondary consideration to him.

4. In the past, and to some degree today, the surgeon chose the anaesthetist himself. In some instances choice depended not on ability, but on willingness to comply with the surgeon's wishes. In the days when the surgeon paid the anaesthetist himself, he might have been the legal master of the anaesthetist. In Canada, today, however, this practice would be considered as fee-splitting, and hence no longer occurs.

In most jurisdictions in the United States, the surgeon is considered to control and supervise the actions of the nurse anaesthetist. The nurse is not considered to be engaged in the practice of medicine. "They are but carrying out the orders of the physicians to whose orders they are subject. The surgeon has the power and therefore the duty to direct the nurse and her actions during the operation" (Chief Justice Waste of the Supreme Court of California) (19).

Even though the surgeon does not employ the nurse, and even though the hospital, rather than the surgeon, bills the patient for the anaesthetic, the surgeon may still be held liable under the "borrowed servant" doctrine. It may be mentioned, parenthetically, that in some United States jurisdictions, unlike Canada, corporations can legally practise medicine. It is considered that the hospital lends the nurse to the surgeon. As quoted in one judgment (16): "Where a servant has two masters, a general and a special one, the latter if having the power of direction and control is the one responsible for the servant's negligence." See also the following cases, 15, 16, 20, 21.

Turning to cases where a physician anaesthetist was concerned, we will consider first an English decision of 1909, the Hillyer case. During an examination under anaesthesia, a patient's arms were allowed to hang over the sides of the table. One was burned on a hot water can, while the other sustained a nerve injury from being pressed against the table. The patient sued the hospital board. The action failed. The Court held that the surgeon rather than the hospital was the legal master of the hospital employees in the operating room, albeit temporarily, and hence the surgeon was vicariously liable for their negligent acts (22).

The relationship between the surgeon and the hospital-employed nurses and porters was very thoroughly examined. The Court stated that although the nurses and orderlies were servants of the hospital, "Once the doors of the operating room close behind them, the surgeon is supreme."

The relationship of the surgeon to the anaesthetist was not considered, but it may be discerned that, at that time and place, it was not thought any business of the "administrator of anaesthetics" to concern himself with the posture of, or prevention of injury to, the patient.

The "surgeon supreme" idea is essentially the same as the borrowed servant doctrine. In this case, it did not apply to the anaesthetist. However, between this decision in 1909 and the English decisions which overruled the principle (8, 9) in 1942 and 1951, the surgeon could conceivably have been held liable for the anaesthetist's negligence, provided the latter was a hospital employee. Although there was a time in Canada when anaesthetists were employed by hospitals, to our knowledge the principle of Hillyer's case was never applied in this way, either in this country or in its country of origin.

In an English decision of 1952 (23), a surgeon was found to have been 80 per cent responsible for an anaesthetic fatality; the anaesthetist only 20 per cent. An out-patient was given nitrous oxide by mask, prior to the debridement of burns. He became hypoxic and unco-operative. It was then realized that some other technique would be necessary, particularly since the burns were on the face. Pentothal was given intravenously, with a fatal result. The surgeon was a resident, qualified two years; the anaesthetist was a junior intern qualified a few months. They were working unsupervised. In this connection, it must be remembered that, at that time in England, a physician became a registered practitioner immediately upon graduation. Nevertheless, in the judgment, the Court castigated the hospital authorities for allowing inexperienced persons to undertake work of this nature.

Apparently the surgeon was in charge of out-patient anaesthesia; furthermore, he made the decision as to the anaesthetic technique. Lord Justice Denning said:

> I find it very difficult to place much blame on Dr. W. [the anaesthetist]. She was not in charge of the operation, Dr. S. was. Moreover, he was in his own words, "responsible for the administration of anaesthetics." He decided to use nitrous oxide. That was the first mistake, or at any rate the cause of all the trouble. Then they decided to use Pentothal. . . . She administered the Pentothal under his very eyes and with his entire approval. Under these circumstances, it seems to me that her share in the responsibility is very much less than his.

So far as we are aware, this is the only instance of a surgeon being held liable for a clear-cut anaesthetic fatality when the anaesthetist was another physician. It will be seen that the surgeon had the right to control, and did control, the actions of the anaesthetist to a very unusual degree. Such circumstances are very unlikely to be reproduced in Canada.

In a British Columbia case of 1951, it was alleged that injury had followed a brachial block (24, 25). Application was made to bring suit against the surgeon, staff anaesthetist, and resident anaesthetist for technical assault. It was held that there was no evidence of negligence in giving the block and that no assault had occurred. However, it was postulated by the Court that had the surgeon engaged the anaesthetist, and had the latter been negligent, the surgeon might have been liable. No decision was made on this point.

In a California case, in 1944, the Court considered the suit of a patient who sustained a brachial neuritis, owing to a shoulder brace (15). The patient sued the family doctor, the surgeon, the doctor owner of a private hospital, and the physician anaesthetist employed by the private hospital. Chief Justice Gibson said: "Although the assisting physicians and the nurses may be employed by the hospital, or engaged by the patient, they normally become the temporary servants or agents of the surgeon, while the operation is in progress and liability may be imposed upon him, under the doctrine of respondeat superior."

A 1957 appeal before the Supreme Court of Colorado is interesting (18). It followed a mishap in Colorado Springs, a few years earlier. The surgeon entered the operating room and gave directions to the orderly as to the positioning of the anaesthetized patient. On the surgeon's request, the orderly went to fetch a strap. The surgeon turned to have his gown tied. The anaesthesioloigst turned around to make chart entries, and at this point, the unattended patient fell off the table, sustaining injury. Subsequently, the surgeon, anaesthesiologist, and orderly were joined as co-defendants. A jury found the surgeon wholly liable. This verdict was considered reasonable and upheld by the appellate court. Justice Day said in his reasons for judgment: "Under the admittedly complex activity in an operating room, it cannot be stated as a matter of law, the exact moment at which the responsibility of the surgeon begins. It is not a matter of law when the sole responsibility of the hospital ends and the surgeon's responsibility begins or supersedes it. These are questions of fact. The surgeon cannot arbitrarily fix the time at which his responsibility begins. His actions set the time."

He also said: "As to Dr. B. [the anaesthesiologist] under the instructions and the evidence, the jury could find that the anesthetist was not required to give

personal attention to the safety of the patient, since she was charged with the responsibility of chart and record keeping. Apparently the jury did so find."

The Court also said: "If, however, the concurrent negligence of two or more persons combined, results in an injury to a third person, they are jointly and severally liable, and the injured person may recover from either or all. The concurring negligence of one is no excuse or defense to the other. . . . the surgeon owed a legal duty to his patient, which he failed to discharge, and such failure constituted the negligence found by the jury."

An appeal heard by the Supreme Court of Kansas, in 1953, reveals a story of clinical as well as legal interest (26). The plaintiff had had an emergency laparotomy. The anaesthetist was a doctor, but whether he was a resident, a practitioner, or a specialist is not apparent from the judgment. For 36 hours after operation, the patient was unable to speak or swallow. Eventually, when she developed cyanosis, an otolaryngologist was summoned. He examined the patient and removed from the larynx a Lumbard oral airway. As recorded in the judgment, the E.N.T. surgeon "held the airway up and said 'Charley [the defendant surgeon], this thing should never have happened.' He then put the airway on the bed. . . . [and] said, 'I have heard of a lot of things, Charley, but this is the first . . . time I have ever seen this.' The defendant picked up the airway and threw it into the hall of the hospital." The remarks of the one and the action of the other are both understandable under the circumstances!

In this case, the anaesthesiologist was not sued, and the surgeon was held liable by both trial and appellate courts. This case, like a Manitoba case of 1949 (27) where a surgeon was successfully sued as the sole defendant following the loss of a foreign body in the throat, proves nothing of itself regarding the subject at hand. It will be noted further that, in the Colorado case, the surgeon was held responsible *directly*, not vicariously liable for the anaesthetist.

Several cases could be cited in which the action against the surgeon and anaesthesiologist was unsuccessful, and where the Court did not feel obliged to consider the question of the liability of the surgeon for the negligence of the anaesthetist although realizing that the question existed. An example would be a New Jersey case in 1957 (28).

We have thus the following positive evidence for the idea of the surgeon as legal master of the anaesthetist: first, the case of the nurse anaesthetist; second, one English case in 1951 (23); third, the doubtful authority of the Hillyer case (10); fourth, one California decision of 1944 (15). Other than this, there seems no firm authority for considering the surgeon to have *vicarious* responsibility for the negligent act of the anaesthetist.

The Anaesthetist as other than a Legal Servant

A fairly substantial body of authority can be brought forward to indicate that the anaesthetist is not the servant or agent of the surgeon. The principle laid down in the Hillyer case, making the surgeon responsible for the hospital employees, has been whittled away till little, if anything, is left (8, 9). Thirty-five years ago the "surgeon supreme" idea was not acceptable to a South African

Court. Chief Justice Innes said that the nurses "are subordinate to the surgeons, but they are in no way their servants. The surgeon is not responsible for what the nurse does, in the sense that the master is responsible for the servant. The surgeon does not insure that he will be responsible for every misfeasance of the nurse" (29).

A 1941 Ontario case (30) is relevant although the anaesthetist was not directly concerned. An assistant surgeon used alcohol to cleanse the skin, prior to surgery. The surgeon applied electro-cautery, which ignited the alcohol, burning the patient. The surgeon alone was sued. Chief Justice Robertson said: "I do not think it can be said, wholly as a matter of law, that at every operation, the chief surgeon is responsible for whatever may occur there, or even that in every case he is liable for negligence on the part of an assistant. Something may depend on the character of the operation, and there may be rules and customs among surgeons that must be taken into account. . . . No case was cited to us, in which the responsibility of the chief surgeon for the negligence of his assistant has been placed any higher than I have stated." This view was affirmed by the Supreme Court of Canada one year later (31).

Extension of the line of reasoning used in these two judgments suggests that if the surgeon is not, in the general case, vicariously responsible for the nurses, or his immediate assistant, his vicarious responsibility for the anaesthetist would be even more doubtful.

An Australian case of 1942 is of importance (32). A patient was being given open-drop ether when the ether bottle fell to the floor and broke, and the vapour was ignited by a nearby open-coil electric fire. As a result the patient's hand, which was hanging over the edge of the table, was burned. An action was commenced against both surgeon and anaesthetist. The trial judge non-suited the plaintiffs. The appellate court, however, held not only that there were grounds for the action, but that the anaesthetist was solely liable, and dismissed the action against the surgeon. Mr. Justice Starke said the surgeon: "was entitled to rely upon the careful administration of the ether by a skilled and competent anaesthetist. No fact was proved, which suggested that he ought reasonably to have anticipated negligence, whether wilful or accidental on the part of P. [the anaesthetist]." The Court also stated that "it is true enough that the operating surgeon was in charge of the operation, and could give directions to the anaesthetist or nursing staff, but they were not his servants or agents."

So far as we are aware, this was the first occasion in the Commonwealth or the United States on which the surgeon and anaesthetist were jointly sued for anaesthetic negligence, and on which the anaesthetist was held solely liable.

In the same year (1942), the case of *Hughston* v. *Jost* was tried before Mr. Justice Hope in Ottawa. This is the precedent referred to in the introduction. A patient brought an unsuccessful suit against an anaesthetist for injury resulting from the extravasation of Pentothal. The surgeon appeared as a witness and not as a co-defendant.

This was the first time in Canada that an anaesthetist had been the sole defendant in such circumstances, but we believe that too much emphasis has been laid on this case. It has been referred to as an index that anaesthesia had "come

of age" as a specialty (2, 7, 34). This may well be so; but when it is represented as authority overruling the master-servant relationship, considered to have existed in Ontario prior to that time (7), we believe it must be approached more cautiously.

Our reasons for doubting its validity as an overruling authority are: first, the patient could have sued any of the parties she wished—this had always been true; second: in the judgment, at least as reported in *Ontario Weekly Notes*, no reference whatever was made to the distribution of responsibility between surgeon and anaesthetist.

It has been suggested that since the Court did not regard the action as frivolous and vexatious litigation, this indicates that the anaesthetist was considered a responsible person. This, however, was surely never in question. It has always been possible to sue the servant alone, even when he has a master. The reason actions are not usually framed in this way is the practical matter of recovering damages.

It is our opinion that the true position is not that *Hughston* v. *Jost* extinguished a prior master-servant relationship, but that such a relationship had never existed in the first place. Judicial opinion about that time was being influenced by other decisions, notably *McFayden* v. *Harvie* in Ontario (30) and *Gold* v. *Essex County Council* (9) in England. It is possible that this influence may have had some effect on the pre-trial proceedings in the *Hughston* v. *Jost* case.

In a 1945 Ontario judgment, relating to a fatality following a spinal anaesthetic (35), Mr. Justice LeBel said:

> No authority has been cited to me that holds as a matter of law, that a physician is responsible for the negligence of the anaesthetist of his choice. It seems to me that the physician has only to satisfy himself that the anaesthetist is duly qualified with the skill and experience necessary for the performance of the professional services he undertakes to perform: having done that, the physician or surgeon is not responsible, as a matter of law, for any act or omission on the part of the anaesthetist.

In an unreported British Columbia case of 1952, which concerned two anaesthetists and a surgeon, the Court concerned itself entirely with the anaesthetist who was alleged to have been negligent. No reference was made to any vicarious liability of the surgeon (36, 24).

An Ontario case (37) in 1955 involved an explosion which occurred while ether was being vaporized in a Flagg can with oxygen. Mr. Justice Smily of the Ontario High Court said in judgment: "It is quite clear on the evidence that Dr. M. [the surgeon] in the circumstances above mentioned could not be said to have been negligent in any respect." The Court found for the defendant surgeon, anaesthetist, and hospital.

The next year an appeal was heard by the Ontario Court of Appeal. During the proceedings the appellants withdrew their case against the surgeon and the hospital. The Court reversed the verdict of the lower court as to the anaesthetist (38), and this was subsequently affirmed by the Supreme Court of Canada (39).

This is the first instance in Canada of a surgeon and anaesthetist being co-defendants in an action for anaesthetic malpractice in which the anaesthetist was found solely liable. It must be noted, however, that it was not laid down *as a*

matter of law that the surgeon was or was not vicariously liable for the anaesthetist. This case was determined on evidence only.

In two English decisions (40, 41), the anaesthetist was held not liable. The surgeons apparently were not joined in the actions. These cases are of little help, therefore, in the present connection.

In the American courts, a case involving a nurse-anaesthetist is very much in point. A nasotracheal tube was inserted by mistake in the oesophagus and the patient sustained a perforated viscus from the pressure of the anaesthetic gases. The surgeon, anaesthetist, and hospital were joined as co-defendants. In dismissing the action against the surgeon, Mr. Justice Donworth of the Supreme Court of Washington noted:

> Dr. H. [the surgeon] testified that Miss R. [the anaesthetist] knew considerably more about administering an anesthetic than he did, and that he left completely to her discretion the administration of the ether to the plaintiff. He also testified that all surgeons in Spokane customarily relied wholly on the nurse anesthetists or physician anesthetists supplied by the hospitals to administer anesthetics during surgical operations. Three other surgeons called by Dr. H. testified to the same effect. [The Court also noted:] Normally the hospital charged patients for the very services which Miss R. was rendering to the plaintiff when this injury occurred.

It is too early to say that this represents a trend to extinguish the previously clear-cut master-servant relationship of surgeon and nurse anaesthetist in most jurisdictions in the United States.

In an Ohio trial in 1941 (13), which involved a broken spinal needle, Mr. Justice Doyle ruled:

> Dr. W. [the surgeon] and the plaintiff entered originally into a consensual contract. At the time, the parties understood that Dr. W. was not to administer the anesthetic, but was to perform the abdominal operation. Dr. W. suggested that Dr. M. [the anaesthesiologist] be engaged. No objection was interposed by the plaintiff. The plaintiff accepted the services of Dr. M., and although Dr. W. actually engaged Dr. M., nevertheless there was created between the plaintiff and Dr. M. a separate contract by implication. Under these circumstances, each doctor was engaged to perform his separate and distinct work, independent of the other.

By coincidence, in this case, as in the case in Ontario in 1945 (35), the surgeon participated in the anaesthetic administration by placing the needle intradurally, after an unsuccessful attempt by the anaesthetist. In neither case was it inferred that this alone rendered him liable for the anaesthetic or the actions of the anaesthetist.

In considering an action arising out of a cyclopropane explosion, Mr. Justice McBride of the Court of Appeal of Louisiana said in 1955 (44):

> There was no negligence or lack of skill or competence on the part of Dr. O. [the surgeon]. . . . There is no substance in the averments that he selected the wrong type of anesthetic, or that the instrumentalities used to administer it were under his control, or that he had control of or supervision of the anesthesiologist, or the equipment, nor can it be said that he was guilty of selecting an incompetent anesthesiologist, for the record shows that he had nothing to do with the choice of Dr. D. [the anaesthesiologist] but rather Dr. D. was selected by the anesthesiological staff of Foundation Hospital. It is true that Dr. O., at one point in his testimony, said that he had done nothing to

prevent the explosion, but we are satisfied with his subsequent explanation, that the operating surgeon is not required to do anything except to make sure that he is garbed in the proper and conventional operating room clothing.

In a 1956 Indiana case, which resulted from a post-spinal, cauda equina syndrome, Mr. Justice Bowen said:

There is no evidence upon which a reasonable inference could be based, that Dr. T. was administering such anesthetic under the control and direction of Dr. McD. [the surgeon]. . . . There is nothing in the evidence, from which an inference could be based, that Dr. T. was not in complete charge of the giving of the anesthetic. . . . The cases uniformly hold that a surgeon is not liable for the negligence of an anesthetist, unless such negligent acts of such anesthetist are committed under such circumstances as impose a duty on the surgeon to correct the anesthetist. . . . To hold Dr. McD. liable under the circumstances shown by this record would establish a rule of law that would make a doctor liable for the reports of a pathologist, who has told a patient that a tissue is cancerous or benign, and for all of the acts and recommendations of other types of similar specialists whose recommendations and acts are in no way subject to the dominion and control of the surgeon.

In a cross-circulation operation for open-heart surgery, the intravenous bottle to the donor patient became empty. This was alleged to have resulted in cerebral damage to the patient. In an action arising out of this mishap (46), District Judge Devitt ruled:

And even assuming that L. [the chief surgeon] was "surgeon-in-charge" or "Captain of the Ship," as urged, does it follow that he is responsible for the negligence, if any, of an anesthesiologist such as Dr. X., assigned to the case by his own superior, exercising his own special medical knowledge in performing his duties without any specific directions from L. I don't think so. . . . to extend the doctrine of respondeat superior to such a situation would be to strain the doctrine beyond the basis for its creation. . . . There is no evidence that L. engaged or directed Dr. X. or any of the others in the operating room, or that he had the authority to do so. The evidence is to the contrary.

A Florida appeal case, in 1958, resulted from an accident during laryngoscopy, following which two false teeth had to be removed from the lung with a bronchoscope (47). Mr. Justice Thomas said in ruling on this case: "The surgeon may have been generally in command from the beginning of the operation to the end, or as the appellants term him in the brief, 'Captain of the Ship,' but it is clear to us that he and the anesthetist [a physician] were working in highly expert fields, peculiar to each, and that despite the common goal, the successful repair of the patient's ulcer, their responsibilities were not inextricably bound together."

A degree of caution must be used before applying the reasoning expressed in the American citations too freely to analogous situations in Canada. American and Canadian law, although similar, are by no means identical. A careful reading of the judgments mentioned indicates that British and Canadian courts are perhaps less likely to find for the plaintiff, than are their counterparts in some American jurisdictions.

As Lord Justice Denning put it in the celebrated Roe and Woolley case (41):

These two men have suffered such terrible consequences, that there is a natural feeling they should be compensated. But we should be doing a disservice to the community at

large if we were to impose liability on hospitals and doctors for everything that happens to go wrong. Doctors would be led to think more of their own safety, than the good of the patients. Initiative would be stifled and confidence shaken. . . . We must insist on due care for the patient at every point, but we must not condemn as negligence that which is only misadventure.

Comparison of this with some of the American judgments indicate that, in some jurisdictions, the courts take a much less liberal view when considering injury sustained during an operation.

Liability of the Anaesthetist for Surgical Negligence

As mentioned earlier, the patient most often makes his prime contract with the surgeon, and a collateral contract is subsequently made with the anaesthetist. Sometimes, however, the situation is reversed and the anaesthetist is considered to be in charge, and engages the surgeon on behalf of the patient.

All the relevant decisions are American and date back quite a few years (43, 48, 49, 50). Reading these judgments indicates that the same principles apply as in the more common situation where the prime contractor is the surgeon. The anaesthetist is not ordinarily responsible for the negligent acts of the surgeon. The words of Mr. Justice Sayre (49) are representative when he ruled:

[the] surgeon did perform the operation, proceeding upon his own judgement, as to what ought to be done and how. . . . The defendant took part only to the extent of administering the anaesthetic. . . . There is no suggestion that, in these things, he showed any lack of skill or committed any error, nor is there any suggestion, in pleading or in proof, that the defendant negligently advised the employment of an unskilful or incompetent surgeon to perform the operation. Under these circumstances the defendant was not responsible for any default of the operating surgeon, who was practising his profession as an independent agent.

Settlements

To this point, we have relied entirely upon court decisions to make the point that the surgeon and anaesthetist are not ordinarily responsible for each other's negligent acts. We will all be aware of settlements made, before trial, where the plaintiffs intended to implicate only the surgeon or the anaesthetist, following some mishap during an operation. We must point out that a settlement does not have any legal force. It is useful however, as an indication that counsel expected a judgment would be rendered against the defendant if the case had gone to trial.

Delimitation of Responsibilities

In the operating room the surgeon concerns himself with the surgical procedure and the anaesthetist with the administration of the anaesthetic. This much is clear. However, there are situations in which it is difficult to determine exactly who has the prime responsibility. This is because of a wide variation of operating room custom and practice across the country. An example of one of these doubtful areas would be the posturing of the patient. This might conceivably be the business of the surgeon, the anaesthetist, or the ancillary personnel.

In attempting to analyse who is responsible for what, some general principles may be laid down.

First, in a malpractice action, the Court would attempt to discover the relevant customs and usage among physicians, from the evidence, particularly from expert testimony. From this, the Court would determine whether a particular defendant's actions were those of a reasonable and prudent man.

Second, as put by Circuit Judge Baker in an Illinois court in 1912:

> Two physcians, independently engaged by the patient, and serving together by mutual consent, necessarily have the right, in the absence of instructions to the contrary, to make such a division of services as, in their honest judgement, the circumstances may require. . . . Each, in serving with the other, is rightly held answerable for his own wrongful conduct, and as well for all the acts or omissions of the other which he observes and lets go without objection, or which in the exercise of reasonable diligence, under the circumstances, he should have observed. Beyond this, his liability does not extend. (48)

Furthermore, everyone in the surgical team is expected to exhibit reasonable care and act in a reasonably prudent manner. Thus, if anyone observes, or should observe, something constituting a hazard to the patient, he would be under a duty to take steps to have it remedied. This applies whether it is within his own immediate province or not, and regardless of his status in the team.

The question of whether he could reasonably be expected to recognize a hazard as such would have to be determined from the evidence. The experience and training of the defendant would be a consideration. Thus, the anaesthetist could not reasonably be expected to recognize as such a careless act of the surgeon if it were of a highly technical nature, obvious though it might be to another *surgeon*. However, he could be expected to recognize as a dangerous act something which should be apparent to any physician. Nurses and orderlies too have responsibility as reasonable persons. The extent of their responsibility is, of course, less than that of physicians, because of the greater training and experience of the latter.

Third, if one owes the patient a direct duty of care, one does not eliminate this duty by delegation to another person.

Fourth, once a person undertakes a task, he must bring to it the requisite skill and knowledge and perform it with reasonable care. Thus, if the anaesthetist undertakes to position the patient, or apply a tourniquet, he accepts much of the responsibility should the patient be injured thereby.

Lastly, it has been our experience that dispute between the surgeon and anaesthetist about the anaesthetic or surgical technique is fortunately very rare. Consideration of such a situation is nevertheless valuable, as it sheds light on the relative disposition of responsibility.

The primary purpose of the operation is the surgical procedure; the surgeon is the prime contractor. This may lead to the mistaken notion that the surgeon's opinion must prevail as to details of the anaesthetic technique. This is not so. Independent of the prime contract is the collateral contract between the anaesthetist and the patient, regarding the administration of the anaesthetic. The notion that the surgeon has the prime duty of care with regard to the anaesthetic, and delegates this to the anaesthetist, is incorrect.

Thus, if *prior* to operation, the surgeon adamantly demands that a particular anaesthetic technique or agent be used, and if in the opinion of the anaesthetist the course of action he is asked to follow is *absolutely* contraindicated, then only one course of action is open to the anaesthetist—he must withdraw from the case. This is not the place to enter into the implications of withdrawal; suffice it to say that the consequences of failing to withdraw at this juncture are potentially more hazardous from the legal point of view than are those implied in submitting to duress. Withdrawal will very rarely be necessary since between reasonable men a compromise can usually be effected.

The question of *relative* contraindication is much less clear cut. The course of action to adopt will again depend on a consideration of the best interests of the patient, and the importance the anaesthetist ascribes to the dangers inherent in the dictated technique. Carl Wasmuth has emphatically stated (51): "The professional judgement and integrity of the anesthesiologist must never be comprised, prostituted or violated." With this sturdy view, we are in complete agreement.

In considering a conflict of opinion of this nature, Mushin has suggested "that the anaesthetist should write down, in the hospital notes, a statement of the difference of opinion and that although he is carrying out the wishes of his colleague, he is doing this as though he were a bona fide junior assistant, acting on the orders of his chief, on whose head the responsibility rests" (52). The anaesthetist misguided enough to follow this advice, and to record the fact that he acted contrary to his own expressed professional judgment, may find that he has furnished documentary evidence of his own dereliction. Murphy and Martin (2) had this to say: "The fact that the anesthesiologist . . . administers the anesthetic under duress and upon instructions from a superior, would not be a defense and even the notation upon the chart of the anesthesiologist's protest would not afford him protection." We agree.

We suspect that the premise on which Mushin based his advice was the fallacious notion that the anaesthetist has the prerogative of diminishing his own status at will, and thereby abridging his liability. This is not so. The disposition of responsibility and the extent of liability are matters for the court to decide, and not subject to the whim of the anaesthetist. If the anaesthetist undertakes to administer the anaesthetic, he alone is responsible, and he alone will be liable if he chooses to accept as an order, irresponsible or fatuous direction, even where it is delivered with every pretension of authority. This applies just as rigorously where the anaesthetist is in some degree subordinate to the surgeon.

During the operation, the anaesthetist cannot withdraw from the case. If *ordered* by the surgeon to do something, which in the opinion of the anaesthetist would be contrary to the best interests of the patient, there is but one proper course of action, from the legal point of view—refusal.

Where a conflict of opinion and interest develops between the surgeon and anaesthetist, and an impasse is reached, either may safely proceed in his own province, once he has put the other on notice. For example, if the patient's condition is deteriorating, the anaesthetist may have to advise the surgeon that the procedure should be abbreviated or terminated, to save the patient's life. He should give his reasons for this opinion. The surgeon, using his professional judgment, must assess this information, apply it to the over-all circumstances,

and act accordingly. If he decides to take the risk and continue, the anaesthetist has fulfilled his duty to the patient by putting the surgeon on notice.

In the same way, the surgeon may put the anaesthetist on notice, by objecting to some detail of the anaesthetic technique. If the anaesthetist, having weighed the relative risks, decides to maintain his existing course of action, the surgeon has fulfilled his duty, and if the patient sustains injury, the anaesthetist would be solely liable, providing negligence could be proved.

For one person to put another on notice in this way, it is essential that the caution be given formally, in such a way as to make it clear that it is a definite warning. The notice must not be couched in casual terms.

The question is sometimes raised as to the best course of action in an emergency situation, where withdrawal is impossible without thereby endangering the patient's safety. The same principles apply. Each individual must proceed in his own area, in accordance with his professional opinion, if necessary putting the other on notice. In doing so, he fully discharges his duty.

Happily, the unpleasant situations outlined above almost never occur. In practice, personal, political, professional, and ethical factors impose themselves on the legal considerations. We feel, nevertheless, that the anaesthetist and surgeon should be aware of their legal position. Armed with this knowledge, there is no reason for one to attempt to force the other to adopt an unreasonable course of action; there will in fact be no grounds for dispute.

The question of disputation has been treated above in terms of its cold legal background. The authors hold views diametrically opposed to those expressed by Professor Mushin, in the one respect mentioned. It must be pointed out that his words have been taken out of context, and apart from the unfortunate legal advice he offers, he treats this matter in a very practical way. Readers are also referred to a relevant annotation in *Lancet* (53) and a letter to the editor of that journal, written by Pask (54).

The view that the surgeon is responsible for *everything* in the operating room is seen to have little support in the deliberations of the courts. The converse view that the surgeon is responsible only for what goes on in the surgical field, and the anaesthetist for everything else, is equally fallacious. If the surgeon and anaesthetist are to pay proper attention to their own work, they cannot concern themselves with the detailed supervision of the whole operating room. At the same time, their responsibility is not strictly limited to what they do themselves. The yardstick for assessing their conduct will always be that of the "reasonable man."

Manifestly Hazardous and Wrongful Conduct of a Colleague

Ordinarily two physicians serving together are not responsible for each other's acts or omissions, yet it has been said: each "is rightly held liable . . . for all the wrongful acts or omissions of the other, which he observes and lets go without objection, or which in the exercise of reasonable diligence, under the circumstances, he should have observed" (48). These statements may appear to conflict. However, we believe the contradiction is only apparent.

The surgeon and anaesthetist develop independent and parallel contracts with the patient in regard to their own spheres of activity. In addition, each, as a reasonable man, owes a duty to the patient covering all phases of the operation. Each engages in his own phase and may ordinarily assume that the other is competent. Such an assumption cannot reasonably be made, if one knows, or ought to know, that the other is incompetent or is acting in a reckless manner. Failure of one to intervent on the patient's behalf, in such circumstances—for example, where the other was obviously intoxicated—would be a breach of direct duty, and hence might amount to negligence. This would apply even if the incompetent person were the more senior member of the team.

The only reported instance of this sort, known to us, was a very recent criminal case in England (55). A consultant anaesthetist had become addicted to drugs, and on the occasion in question, he was administering "Fluothane" to himself, as well as to his young patient. An oxygen tank ran out. The child suffered a cardiac arrest and died a month later as a result. The anaesthetist was found guilty of manslaughter.

The fact that only the anaesthetist was held *criminally* liable does not mean that the parents of the child would have no *civil* remedy against the other people involved, some of whom had known of this unfortunate man's weakness before the disaster. In circumstances of this kind, the associates of the anaesthetist and the administrative authorities concerned might be held to have breached their duty to the patient, in that they failed to suspend the anaesthetist from duty when it became apparent he was acting in a wrongful manner.

The Specialist Certificate

The view has been propounded that the surgeon is responsible for the anaesthetist if the latter is uncertified, but not responsible if he holds the Specialist Certificate. This is not correct. The law does not recognize the certificate of the Royal College of Physicians and Surgeons of Canada. It does, however, give recognition to the fact that some physicians are specialists, while others are not. To quote Judge Advocate Schroeder (38): "Every medical practitioner . . . is bound to exercise that degree of care and skill, which could reasonably be expected of a normal, prudent practitioner of the same experience and standing, and if he holds himself out as a specialist, a higher degree of skill is required of him than of one who does not profess to be so qualified by special training and ability." Jetter puts it this way (56): "Any physician can, so far as the law is concerned, practise as a specialist, regardless of the extent of his training and knowledge. . . . In other words, the specialist assumes the risk of the designation, in return for its awards."

The possession of a specialist certificate will not protect the anaesthetist against charges of negligence if he has failed to bring to a task the requisite skill and knowledge. Its possession, however, is evidence that he has attempted to fit himself for the task he undertakes. On the other hand, if he does not possess a certificate, but does possess the requisite skill and knowledge and undertakes the task with reasonable care, its lack will not weigh against him.

The Surgeon Chooses the Anaesthetist

It will be remembered that where the surgeon chooses the anaesthetist, the former "has only to satisfy himself that the anaesthetist is duly qualified with the skill and experience necessary for the performance of the professional services he undertakes to perform," as Mr. Justice LeBel put it (35). If the surgeon knowingly chooses an incompetent anaesthetist and the patient suffers damage at the latter's hands, both will be directly liable. The surgeon will not be liable because the anaesthetist was negligent, but because he failed in his own *direct* duty to the patient by referring the latter to a person of inadequate ability. It is important to note the use of the word "satisfy." This does not imply any guarantee or absolute warranty of competence, merely a reasonable degree of care in the choice of anaesthetist.

Anaesthetist Not Chosen by the Surgeon

In the larger Canadian hospitals, it has become common practice for the chief of the anaesthetic department to allocate the anaesthetic duties, thus relieving the surgeon of the necessity of arranging for an anaesthetist. It seems fair to say that under these circumstances, the surgeon would be even less responsible for the competence of the anaesthetist than he would be if he chose the latter himself.

Where two doctors have a common patient, neither has to *ensure* that the other is competent. In the very large hospitals, surgeons and anaesthetists collaborate, who are completely unknown to each other. The fact that each has been accorded working privileges in the hospital would constitute reasonable grounds for the assumption by each that the other is competent, in the absence of any evidence to the contrary.

Conclusions and Summary

The manner in which the surgeon and the anaesthetist develop an implied contract with the patient has been outlined. The prime contract is made with the surgeon as to the surgical procedure, and an independent collateral contract is developed with the anaesthetist as to the anaesthetic administration.

The widely held belief that, in the general case, there is a legal or contractual relationship between the anaesthetist and surgeon is incorrect. The relationship between them is comprised of other factors. This is indicated in Figure 1. The relationship developed between them has always been decided on evidence, in each case coming to trial in the past; not as a matter of law, but on matters of fact.

The legal background of negligence, including duty of care and the difference between direct and vicarious liability, has been considered. In contemplating vicarious liability the understanding of what is implied by "control" is crucial. As Friedman puts it: "Whether the physician exercises it or not, it is his right of control which may be the deciding factor on the issue of his liability" (57).

Numerous judgments have been cited from Canadian, British, Australian, and

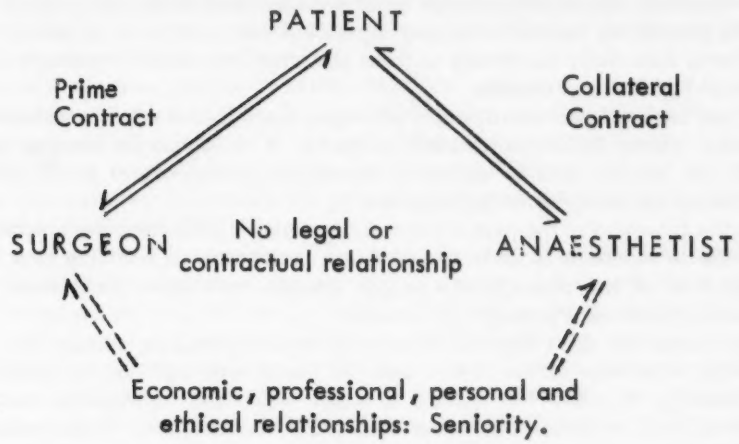

FIGURE 1

(Suggested by Carl Wasmuth)

American sources indicating that the surgeon and the anaesthetist are not liable for each other's acts and omissions. Although they are persons with a common purpose, serving a common patient, they work in highly expert fields, peculiar to each, and their responsibilities are not inextricably bound together. These citations indicate that there are no grounds for believing that there is, or ever was, a legal master-servant relationship between surgeon and anaesthetist. They further indicate that the notion that the surgeon delegates a duty with regard to anaesthesia to the anaesthetist is correct only where it applies to a nurse anaesthetist. If there were any substance to this concept, the surgeon would have been found liable in each of the cases cited since delegation of such a direct duty would not have extinguished the surgeon's duty of care. Thus, in the general case, the surgeon has neither a direct nor a vicarious responsibility with regard to anaesthesia.

A number of other popular fallacies have been discussed in passing. Among these: the concept that the surgeon is responsible for everything that happens in the operating room; the concept that the anaesthetist is responsible for everything in the operating room, other than the surgical field; the notion that the physician's liability is limited to what he does with his own hands.

An attempt has been made to discover the principles governing the disposition of responsibility between different members of the surgical team; in this connection, the question of disputation between surgeon and anaesthetist has been treated at some length. The authors disagree with Mushin's views as to the best manner to act if disagreement occurs, and venture to offer some advice of their own. We feel that if the legal responsibilities of surgeon and anaesthetist were more exactly appreciated than they are at present, the likelihood of argument would be diminished.

If each duly appreciates that the other must not breach his own duty of care to the patient, an amicable working agreement can readily be achieved since neither is then likely to attempt to force the other into conduct contrary to his expressed professional opinion.

It has been pointed out that if a physician chooses to accept, as an order, a demand which, in his professional judgment, is wrongful, he remains solely liable for his own acts or omissions. It will be no defence to plead that he committed the wrongful act under protest.

In the future, as in the past, a surgeon expressing a preference for a particular anaesthetic technique is likely to find that a polite request, implying as it does, recognition of the anaesthetist's proper domain, will more likely meet with agreement than will a peremptory demand.

This paper has dealt with the impersonal legal implications relating to a professional connexion of the closest sort. In practice, it will not be their legal relationship, or rather the lack of it, which will chiefly govern the dealings between two physicians, but rather those other considerations which ordinarily regulate human affairs, and which bear on their mutual purpose. Each must, within his own field, fulfil his duty to the patient, as his own professional conscience shall dictate. The best interests of the patient will be secured, where each, in serving with the other, uses his professional skill in such manner as will best enable his colleague to perform his part of the task. Should one engage in undue harassment of a colleague, this happy alliance must necessarily falter in its purpose.

Acknowledgments

In the preparation of this paper, Dr. Carl Wasmuth of Cleveland, Ohio, offered much helpful advice, doubly valuable because of his unique position as a practising anaesthesiologist with legal training. Among others to whom we are indebted, we would mention Dr. K. G. Gray, Q.C., Dr. Fred Evis, and Dr. R. A. Gordon of Toronto; Dr. T. L. Fisher and Dr. J. H. B. Hilton of Ottawa; Mr. Richard McCauley, Attorney and Counselor at Law of Atlanta, Ga.; Mr. John Green, Q.C., of Regina; Dr. H. B. Graves of Vancouver; Mr. P. H. Maguire, Q.C., Mr. E. V. Wahn, D.H.A., Mr. Eric Diehl, and Dr. K. B. Lazarus, of Saskatoon; Miss E. Bell, Librarian of the College of Law, University of Saskatchewan; Mr. Pete Estrada and Mrs. Helen Ruhl, Librarians of the Maricopa County Law Library, Phoenix, Ariz.

Résumé

Nous avons décrit la façon pour le chirurgien et pour l'anesthésiste de créer une entente implicite avec le malade. Le premier contact s'opère avec le chirurgien concernant les détails opératoires et une entente collatérale indépendante se fait avec l'anesthésiste en ce qui concerne l'anesthésie.

La croyance répandue que, en général, il existe, entre le chirurgien et l'anesthésiste, un rapport légal ou contractuel n'est pas exacte. Le rapport qui existe entre eux concerne d'autres facteurs. La figure 1 l'indique.

Le rapport qui existe entre eux a toujours été accepté comme évident, dans le passé, dans tous les cas qui ont conduit au procès, non pas comme matière de loi, mais comme matière de fait.

Nous avons tenu compte du terrain légal de négligence, y compris le devoir de soins et la différence entre la responsabilité directe et vicariante. En parlant de responsabilité vicariante, la compréhension de ce qui est impliqué dans le "contrôle" est cruciale. Ainsi s'exprime Friedman: "Que le médecin l'exerce ou non, c'est son droit de contrôle qui peut être le facteur déterminant de l'étendue de sa responsabilité" (57).

Nous avons cité de nombreux jugements de sources canadiennes, anglaises, australiennes et américaines attestant que le chirurgien et l'anesthésiste ne sont pas responsables des actes et des omissions de l'un et de l'autre. En dépit du fait qu'ils soient des personnes visant un but commun, au service du même malade, ils travaillent dans des domaines très spécialisés, particuliers à chacun, et leurs responsabilités ne sont pas liées de façon inextricable. Ces citations nous indiquent qu'il n'y a pas de bien-fondé pour croire qu'il y a ou qu'il y a eu de rapport légal de maître à serviteur entre le chirurgien et l'anesthésiste. Ces citations laissent entendre de plus que la notion que le chirurgien délègue ses devoirs à l'anesthésiste en ce qui regarde l'anesthésie n'est exacte que s'il s'agit d'une infirmière anesthésiste. S'il avait existé substance à un tel concept, le chirurgien aurait été tenu responsable dans chacun des cas cités puisque la délégation d'un tel devoir direct n'aurait pas exclus le devoir de soins du chirurgien. Ainsi, dans le cas ordinaire, le chirurgien n'a ni une responsabilité directe ni une responsabilité vicariante en ce qui concerne l'anesthésie.

En passant, nous avons discuté un nombre d'autres faussetés populaires. Entre autres choses: la croyance que le chirurgien est responsable de tout ce qui peut arriver dans la salle d'opération; la croyance que l'anesthésiste est responsable de tout ce qui arrive dans la salle d'opération, en dehors du domaine chirurgical; la croyance que la responsabilité du médecin est limitée à ce qu'il fait de ses propres mains.

Nous avons essayé de découvrir les principes régissant le partage de la responsabilité des différents membres de l'équipe chirurgicale; à ce point de vue, la question de conflit entre le chirurgien et l'anesthésiste a été exposée plus longuement. Les auteurs diffèrent d'opinion avec Mushin sur la meilleure façon d'agir s'il existe un désaccord entre les deux et ils vont même jusqu'à donner leurs conseils personnels. Nous avons la conviction que si les responsabilités légales du chirurgien et de l'anesthésiste étaient plus exactement précisées qu'elles ne le sont dans le moment, l'attitude de conflit serait diminuée.

Si chacun évaluait exactement que l'autre ne doit pas modifier son devoir de soins au malade, une entente amicale de travail pourrait exister, puisque ni l'un ni l'autre n'essaierait de forcer l'autre à agir contrairement à l'opinion professionnelle qu'il exprime.

Il a été démontré que si un médecin choisit ou accepte comme un ordre une demande que, dans son jugement professionnel, il estime fausse, il demeure entièrement responsable de ses actes et de ses omissions. Il n'y aura pas de défense à plaider qu'il a commis un acte à tort comme protêt.

A l'avenir comme par le passé d'ailleurs, un chirurgien qui manifeste une préférence pour une technique anesthésique se rendra à l'évidence qu'une demande polie, supposant comme elle le fait, la reconnaissance du domaine propre de l'anesthésiste, sera plus susceptible de recevoir une adhésion qu'une demande péremptoire.

Dans cet article, on a discuté des aspects légaux impersonnels en relation avec une situation professionnelle des plus rapprochées. En pratique, ce ne sera pas l'existence ou l'absence de leur statut légal qui présidera au commerce entre ces deux médecins mais plutôt d'autres considérants qui régissent ordinairement les affaires humaines et qui influencent leurs intentions réciproques. Chacun doit, dans son propre domaine, remplir son devoir envers le malade, comme le lui dicte sa conscience professionnelle. Ainsi seront sauvegardés les meilleurs intérêts du malade lorsque chacun, en collaboration avec l'autre, se sert de sa dextérité professionnelle pour permettre à son collègue de réaliser sa part de devoirs. Si quelqu'un acquiesçait à la soumission indue d'un collègue, cette heureuse alliance laisserait nécessairement planer des doutes sur son but.

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A YEAR OF PAEDIATRIC CARDIOVASCULAR ANAESTHESIA

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PAEDIATRIC CARDIOVASCULAR ANAESTHESIA necessitates the application of the basic principles of anaesthesiology at a very high critical level. Maximal oxygenation of the patient is paramount. The anaesthetic agent employed should be non-explosive, easy to reverse, and have minimal side-effects, especially on the cardiovascular system. Many methods of anaesthesia, utilizing various combinations and permutations of pharmacological agents, are being used successfully. The methods vary; the principles are the same. This is an account of one such method, employed the past year at the Hospital for Sick Children, Toronto.

METHOD

Assessment of the patient. The patient is carefully examined preoperatively with special reference to the type of anomaly and the degree of cardiac failure. Certain anomalies, best exemplified by total anomalous pulmonary venous drainage, attenuate the conduct of anaesthesia considerably.

Premedication. Atropine gr. 1/5,000/lb. approximately and meperidine 0.75 mg./lb. is given ½ hour preoperatively. Exceptions to this rule are the older apprehensive children who are given morphine, and poor risk infants to whom atropine alone is given under direct supervision. Light sedation is successfully employed at this hospital as the children awaiting surgery are "mothered" and generally entertained.

Induction. Thiopentone 2½ per cent is injected very slowly in a minimal "sleeping" dose. An endeavour is made throughout to use all pharmacological agents by a titration technique. The aim is to give the least amount possible to gain the desired effect. A time/patient/defect relationship is considered at all times.

Intubation is carried out with the aid of succinylcholine after spraying the cords with 5 per cent hexylcaine. Infants are induced with Fluothane, or oxygen alone is used, before intramuscular succinylcholine is given for intubation. Hexylcaine is not employed in this instance.

Adequate oxygenation with close supervision of the patient is the essence of the technique.

Maintenance. Fluothane in the percentage range of 0.5 to 1.0 is generally adequate. Oxygen is the vaporizing agent.

Respirations are controlled when surgery of the chest is begun. Infants are controlled throughout. Hyperventilation is employed.

Succinylcholine chloride in the dilution of 1 mg./10 lb./ml. is connected to the intravenous. To avoid over-hydration in infants under 20 lb., the dilution is not

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taken below 2 mg./1 ml. The succinylcholine is used to posture the patient under hypothermia, to test compliance, and to control the patient during extracorporeal circulation occlusions. It has been found that the amount of succinylcholine used is in inverse proportion to the experience of the anaesthetist in this technique.

Infants as a rule are difficult to keep anaesthetized with Fluothane under a 2.0 per cent concentration. A combination of 1.0 per cent Fluothane with intermittent intramuscular or intravenous succinylcholine is a good alternate.

Preservation of function. Preservation of physiological function in cardiovascular patients is frequently more difficult than usual. The control of anaesthesia in relation to function necessitates, in many instances, the use of instrumentation as an adjunct to the "five senses."

Various combinations and permutations of the following monitors have been used: oesophageal stethoscope; endotracheal pressure manometer; oesophageal thermometer; oscillometer; arterial manometer; superior and inferior vena caval manometers; electrocardiograph; electroencephalograph; direct intracardiac manometer; oxygen saturation recorder; rectal thermometer; and qualitative and quantitative area dye dilution apparatus.

Temperature is controlled by a twin tank (hot/cold) blanket arrangement.

Blood volume must be maintained and it is essential to ensure adequate facilities for rapid blood replacement based on a clinical appraisal of the patient, utilizing the instrumentation, measurement of suction, weighing of sponges, and weighing of the patient.

Blood chemistry is monitored by a pH meter and laboratory facilities are readily available. Instrumentation is also used in the recovery phase.

Post-anaesthetic care. The patients are taken to the recovery room awake and in physiological balance. The same diligent supervision of the patient is employed here as in the operating room. Meperidine, in a dose 1 mg./10 lb. intravenously, is used for pain relief.

Maintenance of maximal oxygenation necessitates control of "splinting" due to pain, adequate drainage of mediastinal and chest cavities, clearing of the airway by oronasal or bronchoscopic suction, and the treatment of cardiac failure. The intermittent use of positive pressure, either manually or mechanically, may be necessary to ensure adequate ventillation. The use of dry gases is discontinued as soon as possible. Blood volume and acid/base balance are controlled as before.

The commonest pharmacological agents used are: Aminophyllin and Cortisone for bronchospasm; Prostigmine for supraventricular tachycardia; Isuprel, Acetylstrophanthidine, and Digoxin for cardiac failure; and calcium gluconate to obviate citrate intoxication.

Constant care of the patient continues as long as necessary. This time varies from hours to days.

Factor of basic pathology. To illustrate the defect/age/weight relationship of our series, Table I is presented. No attempt is made to classify the defects in detail or to illustrate the important factor of secondary change, such as pulmonary hypertension; but it should be remembered that many of the anomalies present individual anaesthetic problems. It is only with a full understanding of the anomaly that the problems can be appreciated. The significant factor of the

TABLE I

Defect	No.	Age range	Weight range (lb./oz.)
Hypothermia			
Coarctation of the aorta	19	4 wks.–12 yrs.	7/3 – 106
Tetralogy of Fallot	15	4½ mo.–15 yrs	9 – 75
Tricuspid atresia	8	3 mo.–2 yrs.	7/10 – 20
Single ventricle	3	3–11yrs.	30 – 55
T.A.P.V.D.	1	8 wks.	9/3
Pulmonary atresia and P.D.A.	1	8 wks.	10/6
A.S.D. secundum.	30	4–14 yrs.	35 – 91
Pulmonary stenosis.	14	1 wk.–15 yrs.	5/6 – 112
A.S.D. primum.	1	14 yrs.	105
Extracorporeal circulation			
V.S.D.	34	3 mo.–14 yrs.	9 – 99
Aortic stenosis.	3	2–12 yrs.	26 – 98
Aortic and mitral stenosis	1	15 mo.	13
Tetralogy of Fallot	8	3– 5 yrs.	26 – 37
A.S.D. secundum.	2	11–15 yrs.	59 – 80
Miscellaneous	2	6–10 yrs.	34 – 55
Transposition of G.V.	4	2 wks.–23 mo.	6 – 15/9
A.S.D. and mitral cleft	7	2– 5 yrs.	26 – 36
T.A.P.V.D.	7	2 mo.–11 yrs.	10/3 – 80
P.A.P.V.D.	4	9–15 yrs.	61 – 91
Others			
Vascular rings	2	2 mo.–14 mo.	14/13 – 22
P.D.A.	38	3 wks.–15 yrs.	7/10 – 155

anomaly may modify responses to drugs. For example, in the patient with tetralogy of Fallot, the slow circulation time delays the onset of sleep following the injection of thiopentone. The pathology may be multiple, involving varying pharmacological and mechanical controls of respiration. This is very well demonstrated in a patient with a vascular ring pathology. These rings compress the trachea either preoperatively and/or postoperatively.

In addition, not only do these children frequently present as repeated pneumonitides, but there is often concomitant congenital malformation of the tracheobronchial tree. It should suffice to mention that one of these children, after having been vigorously treated with antispasmodics for bronchospasm during the operation, presented a very difficult mechanical factor postoperatively. This involved eleven bronchoscopic suctions in as many days.

The manner in which an anaesthetic technique can materially benefit the welfare of a group of patients is well seen in the correction of the anomaly of coarctation of the aorta. Previous to the introduction of Fluothane, the mainstay of anaesthesia was nitrous oxide/oxygen with intermittent decamethonium and succinylcholine. When the aorta was occluded, Arfonad was frequently necessary to control the resulting hypertension. Again, on removal of the clamps, a vasopressor had to be employed to control the sudden hypotension. To replace this high-dose relaxant technique with its inherent dangers, Fluothane was chosen. Not only did it afford a method of using 100 per cent oxygen to ventilate, but also, in our opinion, it satisfied the criteria for a cardiovascular anaesthetic. This we believe has been borne out in practice. Fluothane in the range of 0.5–1.0 per cent does not act as an irritant to the pulmonary and cardiovascular systems.

Cardiac output determinations were done but not in sufficient quantity to be statistically significant, but it appears that in the range 0.5–1.0 per cent. Fluothane does not materially affect the cardiac output. The most remarkable finding during the use of Fluothane has been the excellent stability of the patient's cardiovascular system. At no time since the advent of Fluothane have Arfonad and vasopressors been used during the correction of coarctation of the aorta.

Factor of Occlusion. Following either an extracorporeal or a hypothermic occlusion, nitrous oxide 60 per cent with oxygen given by hyperventilation is usually adequate, at least for a considerable time. It is also preferable to use this technique at the end of the operation as Fluothane has a longer "wake-up" time.

Factor of age. Infants present a multitude of problems, only a few of which will be mentioned here. Many of the poorer risk infants do not tolerate any degree of anaesthesia. It is our custom to ventilate with 100 per cent oxygen and use intermittent succinylcholine after adequate atropine to keep the child still. Great care is taken that the retracted lung is frequently inflated and that major vessels are not accidently occluded. Every facet of the method is modified by the infant. It is found, for example, that the best guide for blood replacement in the operating room is direct vision of the atria; while in the recovery room, the venous pressure of the "cut-down" is a valuable index. Many infants warrant surgery on an emergency basis. There is no time to check acid/base balance and to attempt to bring it within physiological limits. Thus, postoperatively, diligent watch must be made for acidosis. This may arise on the second or third day after the operation. These infants must be vigorously treated and it is often necessary to ventilate them manually to ensure adequate oxygenation. In infant care, normal trials and tribulations are magnified a thousand times, but there is something peculiarly satisfying in the reward of success. These infants have a normal life expectancy.

Factor of constant care. The recovery phase is, in our opinion, no less important than the operative one. The same constant care is not only desirable, it is an absolute necessity. Three illustrations should suffice to demonstrate the degree of vigilance necessary.

Eight hours postoperatively a main ventriculotomy suture breaks. There is a massive tamponade and cardiac arrest. There is an anaesthetist and surgeon present. The heart is restarted and repaired instantly. The child has no sequelae.

One hour postoperatively a 40 lb. child has a cardiac arrest. Surgeons and anaesthetists are present. The heart is restarted, but it is found that it is impossible to adequately inflate the lungs manually. A Bennet Assistor is then used at its maximum speed and ventilatory power. Gradually the lungs (which have a consistency of liver) inflate, and adequate oxygenation is achieved. The child is well.

Four hours postoperatively, a 30 lb. child does not appear to be progressing satisfactorily. Although pulse and blood pressure are normal, the pallor of the child indicates blood loss unaccounted for and/or inadequate ventilation. The right main bronchus occludes and bronchoscopic suction is immediately carried out with minimal success although the right lung has now good air entry. But on returning the patient to the recovery room, there is again diminished air entry on the right side. Again bronchoscopy is carried out and the bronchoscopist states that the right stem bronchus is now compressed, which it had not been on the first examination. A thoracotomy is performed and a large amount of clots removed. The child rapidly begins to improve.

These brief illustrations of success following constant care should serve to make one aware that the anaesthetist must not relax his vigilance and degree of service immediately postoperatively.

Summary

A method of anaesthesia for paediatric cardiovascular surgery has been presented. It has been used successfully for the past year at the Hospital for Sick Children, Toronto.

ANAESTHESIA WITH HYPOTHERMIA FOR CLOSURE OF ATRIAL SEPTAL DEFECTS IN CHILDREN

A. W. Conn, M.D., B.Sc.(Med.), F.R.C.P.(C), David Allan, M.B., and C. I. Junkin, M.B.[1]

The Atrial Septal Defect is a lesion which can now be operated on with great success. It has a high incidence in congenital heart disease forming 17 per cent of one large series (1), and 7 per cent of a large paediatric group (2).

The lesion arises from embryological failure of apposition of parts of the intratrial septum. There are four main types of intratrial openings, each with many sub-groups, and any combination may occur (3). These may be described as follows:

(*a*) Probe-patent foramen ovale: this opening is usually closed functionally but may have an inadequate valve.

(*b*) Ostium secundum defect: an opening is present usually in the central portion of the septum; a common variant is the "high" secundum defect which occurs close to the superior vena cava and is accompanied by partial anomalous pulmonary venous drainage (4).

(*c*) Ostium primum defect: an opening is present in the lower portion of the atrial septum with the lower rim formed by the junction of mitral and tricuspid valves (usually abnormal).

(*d*) Atrio-ventricularis communis defect: this defect is similar to ostium primum defect but is accompanied by failure of fusion of the valve tissue and an underlying ventricular septal defect.

The first two groups are the only lesions suitable for direct closure under hypothermia. The time limitation imposed by hypothermia is approximately 8 minutes at 30°C., and the second two groups usually require a longer period.

Pathological Physiology

The atrial septal defect (ASD) produces its deleterious effects by altering the normal circulatory haemodynamics. With an intact atrial septum, the left atrial pressure is 5 mm. Hg higher than right atrial pressure (5). With a small ASD there is a pressure gradient of approximately 3 mm. Hg producing a left to right shunt. With a larger defect (2 sq. cm. or greater) the pressure difference is practically abolished and the two atria function as one. With equal filling pressure the right ventricle receives considerably more blood than the left ventricle owing to its greater distensibility in diastole. The flow through the pulmonary circulation may be two to four times that of the systemic circulation, but the right ventricle adapts well to such volume loads in contrast to the left ventricle (6). Usually the pulmonary pressure remains normal or only slightly elevated for many years, illustrating the capaciousness of the pulmonary vascular bed.

Ultimately, right ventricular failure occurs, either directly, or secondary to pulmonary vascular changes producing pulmonary hypertension. As the ventricle

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fails, the atrial shunt may reverse and produce cyanosis. Atrial fibrillation develops in approximately 10 per cent of cases (8).

Prognosis

Deaths from this lesion are very rare in infancy (1, 7). Serious symptoms or signs are rare at age 20, but gross cardiac enlargement occurs in half the cases by the age of 40 (8). Campbell *et al.* (9) report that 95 per cent are doing well at age 20, and 85 per cent are doing well at age 30, but from then on deterioration is rapid. The average age at death from uncomplicated ASD is 49 years (10). The great variability in the natural history of this disease makes it impossible to predict which patients are destined for longevity and which will develop pulmonary hypertension (11). The only contra-indication to operation may be those cases with moderate to high pulmonary hypertension associated with a high diastolic pressure and normal or slightly elevated pulmonary flow. Most patients under 45 years of age should have surgery undertaken as soon as the diagnosis is made (12, 13). The age group 2 to 10 years carries the minimum risk.

Anaesthesia

The first successful closure of an atrial septal defect using direct vision, with the aid of hypothermia, was reported by Lewis in 1953 (14). Since that time this method has become increasingly popular because it is simpler than using a cardiac by-pass, more effective than "blind" procedures, and is very safe (1, 12, 15–18). This paper deals with 63 paediatric cases which were diagnosed as having uncomplicated atrial septal defects of the secundum type and came to operation. The ratio of males to females was 23 to 40 which tends to confirm a slightly increased incidence in females. The ages range from 4 to 16 years and are subdivided as follows:

	4–7 years	*8–11 years*	*12–16 years*
Male	7	11	5
Female	18	15	7

Preoperative Visit

The patient must be thoroughly examined preoperatively by the anaesthetist. Any complicating illness results in cancellation of the operation because the procedure is elective in children. The cardiovascular system is examined in detail. A precordial "heave" due to right ventricular hypertrophy and a "thrill" in the pulmonary area may be palpated. An ejection-type systolic murmur in the second left interspace, due to relative pulmonary valvular stenosis with an accentuated, widely split pulmonary second sound, confirms the presence of increased pulmonary flow. Jugular venous distension or hepatomegaly due to right ventricular failure must be ruled out. The electrocardiogram reveals right axis deviation, right ventricular hypertrophy, and right bundle branch block. An X-ray photograph of the chest shows a prominent pulmonary artery bulge

and increased vascular markings. A point of importance is the haemoglobin level, which must be over 10 gm. per cent as considerable blood loss can occur.

Premedication consists of meperidine (0.75 mg./lb.) and atropine (.012 mg./lb.). Morphine is used in older patients in a dosage of 1 mg./10 lb. body weight. Sedation is minimal, as apprehension is rarely a prominent feature and drug depression must be avoided.

Induction

The patient is carried into the operating room while a cheerful conversation is maintained to provide distraction. Using 2½ per cent thiopentone, a "sleep" dose is administered very slowly intravenously, followed by succinylcholine (1 mg./3 lb.). With the onset of complete relaxation and following adequate ventilation, the larynx is sprayed with 5 per cent hexylcaine. Unhurriedly, the patient is intubated using a Portex Magill tube, and its position is checked by stethoscope. The patient is artificially ventilated with a nitrous oxide–oxygen mixture (60:40) until spontaneous respirations return, and then Halothane is added. An 18-gauge needle with stylet is inserted in the right saphenous vein at the ankle to serve as a "spare" entrance to a vein. A cut-down is started in the left saphenous vein and a blood pump administration set[2] is connected. Intravenous extension tubing[3] is used to allow the blood pump to remain at the head of the table. Thus, fluid balance is easily controlled by the anaesthetist. After the various monitoring devices are connected, cooling is started.

Maintenance

The key-note of cardiovascular anaesthesia is the maintenance of the lightest possible plane at all times. Early in this series, nitrous oxide–oxygen anaesthesia was enhanced by "light" ether or cyclopropane during cooling. At the suggestion of one author (D.A.) Halothane was substituted and it now used throughout the operation, replacing nitrous oxide/oxygen/relaxant combinations. However, a syringe connected to the intravenous tubing and containing succinylcholine (1 mg./10 lb./cc.) is retained for occasional use. Owing to the presence of electrical apparatus and the use of the cautery, a non-explosive anaesthetic is necessary. Halothane is administered using a Fluotec Vaporizer, and it has been found that adequate anaesthesia with controlled respirations and minimal cardiac depression can be obtained with concentrations of 0.5 to 1.0 per cent. A spring-loaded expiratory valve with a unidirectional valve added is situated adjacent to the endotracheal tube, producing a non-return system but requiring high gaseous flow.

Respiratory control is instituted as soon as the incision is made, and hyperventilation is maintained until the chest is closed. This method produces adequate oxygenation, avoids carbon dioxide retention, enables a lighter plane of anaesthesia to be maintained, and inhibits increased ventricular irritability (19). To follow the positive pressures in the airway, the suction end of a Magill Endotracheal Connector is connected to a gauge calibrated in centimetres of water.

[2]Abbott Laboratories, North Chicago, Ill.

[3]Baxter Laboratories Incorporated, Moreton Grove, Ill.

In keeping with the pharmacological principle of titration, drugs are administered in repeated small doses until the desired effect is produced, or side-effects result. For example, atropine is given intravenously in doses of 0.3 mg. when bradycardia occurs and Prostigmine in doses of 0.1 mg. when tachycardia occurs.

Blood loss is carefully calculated and accurate replacement is made. Blood-soaked sponges are weighed, blood loss through suction is measured using a calibrated glass flask fastened to intravenous pole (kept at eye level), and blood loss on drapes is estimated. Both loss and replacement are charted on the operating room blackboard.

Following closure of the defect, a good nitrous oxide anaesthetic has been established and other agents are no longer required.

With the incision closed, hyperventilation is discontinued and spontaneous respiration commences. When the oesophageal temperature is 33°C., nitrous oxide is discontinued and consciousness returns promptly.

The patient is transferred to the recovery room where the anaesthetist has complete charge of the patient for the initial four hours. The anaesthetist must *not* be a mere technician but a physician who accepts responsibility for all his actions. Only thus does he become a colleague of equal status on a team. The stage may be set in the operating room for many of the immediate postoperative complications, such as, shock from inadequate replacement, cardiac failure from overload, atelectasis from inadequate bronchial suction or ventilation, and pneumothorax or haemothorax.

Monitoring

A cardinal principle of cardiovascular anaesthesia is to ascertain the patient's reaction to stress in every possible way. An oesophageal stethoscope is inserted immediately after induction to follow cardiac rate and rhythm as well as air entry. Blood pressure is taken with a Collens Oscillometer, which enables both systolic and diastolic pressures to be determined. Even with this sensitive instrument, it may be difficult to determine the blood pressure due to peripheral vasospasm and low stroke volumes; the result of hypovolemia and/or hypothermia. Palpation of the carotid vessels and the loudness of the heart sounds provide a temporary index of the patient's condition until the blood pressure can be determined.

A Sanborn (150 M. series) six-channel recorder with a four-channel visoscope is used. The electrocardiogram is used to determine cardiac rate and any type of arrhythmia which may occur. Needle electrodes are used to avoid constricting bands on the extremities. The electroencephalogram is also followed, but interpretation is more difficult. E.E.G. tracings are completely *flattened* within 15 to 20 seconds following application of the caval tourniquets. Tracings return to their previous pattern within 2 to 4 minutes after release of tourniquets if the circulation is adequate. Transducers are immediately available for direct pressure recordings when desired. Dye studies with Coomassie Blue[4] using an oxygen cuvette

and a Waters Oximeter Control Box can be set up to check on the closure of the defect on the table.

HYPOTHERMIA

Cooling

The patient is placed on the operating room table on a Thermo-O-Rite[5] blanket covered by a cotton sheet. After induction of anaesthesia, ice bags are placed alongside the patient, and over the axillary and inguinal areas. The refrigerant (at a temperature of 32°F.) is then circulated and the patient enclosed in the mattress. Ice is placed on the skin of patients over 75 lb. in weight, but only in small amounts. The use of ice and ice baths in infants has been discontinued because of the difficulty in reversing the rapid falls in tem-

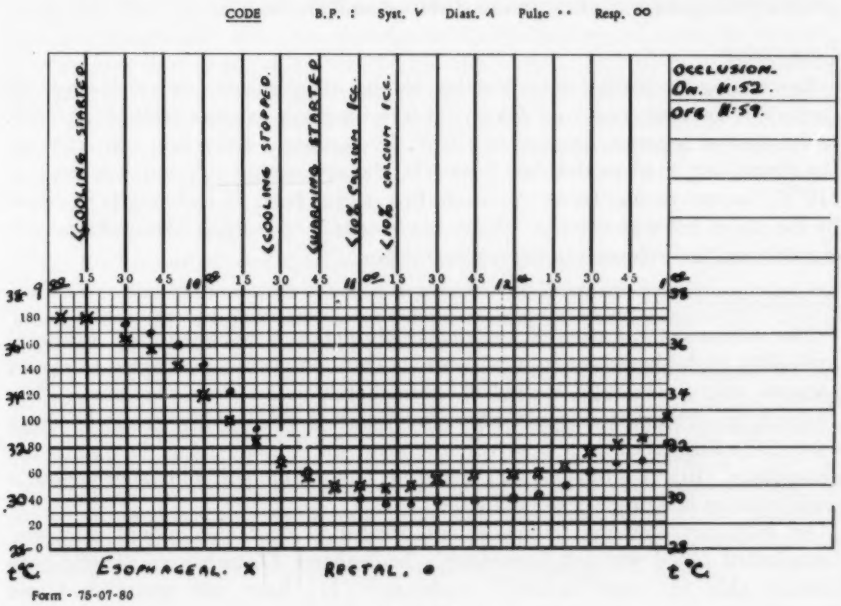

FIGURE 1

peratures that ensue. As an example, one infant, removed from an ice bath at 35°C., cooled to 28°C. despite all efforts at rewarming. At temperatures below 33°C., movement of the patient should be minimized to avoid undue stimulation of a hypothermic heart. Both oesophageal and rectal temperatures are taken and recorded. It is unfortunate that no simple, inexpensive, automatic recording device is available (20). An actual temperature chart is illustrated in Figure 1.

[4]Courtesy of Ayerst, McKenna and Harrison, Limited, Montreal, P.Q.
[5]Thermo-O-Rite Company, Limited, Buffalo, N.Y.

Drift

Drift depends on (i) the size of the patient, (ii) degree of muscle tone, (iii) the amount of peripheral vasodilation, and (iv) ambient temperature and humidity (21). Excessive subcutaneous fat appears to be an important factor as it hinders rewarming by providing a layer of insulation. Considerable individual variation exists and the best indication of subsequent temperatures is the slope of the temperature curve. As the slope steepens, cooling should cease at higher temperatures because the drift will be greater. It appears wiser to cool a patient more slowly and thus retain more control over the temperature.

Closure was performed in our early cases at rectal temperatures of 28° to 29°C. The oesophageal temperatures were likely much lower, and ventricular fibrillation was common. With experience and shortened occlusion periods, rectal temperatures of 31° ± 1°C. or oesophageal temperatures of 30° ± 1°C. are perfectly adequate and allow time for unforseen difficulties.

Rewarming

Rewarming is instituted according to the temperature and the stage of surgery. The latest model of Thermo-O-Rite machine has one solution at 32°F. and a second separate solution at 105°F. By turning a valve one can alternate the circulating fluid as desired. Formerly, the rewarming solution was kept at 110°F., but one patient received a slight first degree burn. Rewarming is hastened by the use of hot water bottles. When the temperature reaches 33°C., the patient is awakened and returned to the recovery room.

Complications

The serious complication of ventricular fibrillation is related to the increased irritability of the heart due to hypothermia. This complication occurred in eleven patients and invariably happened immediately after the occlusion. "The asphyxiated, manipulated, cold abnormal heart is particularly prone to enter ventricular fibrillation at a time when an attempt is being made to restore the circulation" (19). It is obvious that numerous factors summate to trigger ventricular fibrillation in a predisposed individual.

An increased bleeding tendency was present in only one patient in whom heparinized blood was not immediately neutralized. Disturbances of acid-base balance akin to "acute acidotic syndrome" (21) have not occurred. Gross shivering is only seen in children over the age of puberty, but increased muscular tone is constant. Mild degrees of metabolic acidosis probably occur even with short occlusion, moderate hypothermia, and light anaesthesia with hyperventilation. Children can apparently compensate for mild degrees of acidosis, but unfortunately no complete biochemical studies have been undertaken in this series.

Occlusion

Before Occlusion

Immediately preceding occlusion of the heart, the anaesthetist has certain responsibilities. (*a*) Blood loss is balanced, using citrated blood. Then, hepari-

nized blood is used to replace blood lost during occlusion. Heparinized blood is preferable to citrated owing to the rapidity of replacement sometimes required, and the difficulty of accurately balancing the citrate with calcium to avoid citrate intoxication. Citrated blood may also be a factor in causing ventricular fibrillation (20) (a minimum of 500 cc. must be on hand in the operating room at this stage). The heparin content of blood used during the occlusion is calculated and neutralized by an equivalent dose of Polybrene.[6] (*b*) A small amount of succinylcholine is injected to reduce diaphragmatic movement during the closure. (*c*) For 30 seconds preceding the occlusion 100 per cent oxygen is administered. (*d*) An ether hook is placed at the edge of the incision and connected to a special carbon dioxide cylinder unrelated to the anaesthetic. A flow of 6 L./min. is used to form a "blanket" of carbon dioxide over the atrial defect. Carbon dioxide is more soluble in blood than air, and it is hoped that by this method carbon dioxide will displace air that inadvertently enters the left atrium. (*e*) The anaesthetist times the duration of application of the caval tourniquets. The average time in our series was 4.6 minutes with a range of 2¾ to 7½ minutes. At the end of 5 minutes, the time is called so that the surgeon can decide whether sufficient time remains to complete the procedure. Although the necessity has not arisen, the repair can be done in multiple stages as suggested by Johnson (21).

During Occlusion

Gas flow is cut off and the lungs allowed to collapse during occlusion. When the final suture in the defect is being tightened, the lungs are inflated, forcing out blood which fills the left atrium, and displacing air. If ventilation occurs before this time, the operative site is hidden by blood.

In a child the average blood loss due to emptying of the heart chambers and adjacent vascular beds approximates 200 to 300 cc. This volume is lost in the first 2 minutes of occlusion and should be immediately replaced. If more blood than this is suctioned, then the possibilities of a loose caval tourniquet, a "missed" left superior vena cava, or distortion of the heart with back flow through the aortic valve must be considered. Corrective measures have to be instituted immediately to avoid massive blood loss. It should be obvious that the presence of two or more anaesthetists is obligatory during this stage.

After Occlusion

Commencing within 1 minute of the release of the caval tourniquets there is a rapid rise of systolic and diastolic blood pressures, occasionally reaching levels of 230/130 within 5 minutes. During the subsequent 20 to 40 minutes a gradual fall in the blood pressure occurs until it reaches normal levels. The cause of this hypertensive phase is not certain. The characteristics of the blood pressure changes suggest a sympathomimetic source. Some rise in blood pressure usually occurs, but *not* if marked hypovolemia is present, if an associated pulmonary stenosis exists, or if the heart is beating inadequately for any reason.

Blood loss is again calculated and oxygen is administered until fluid balance is

[6]Supplied by Abbott Laboratories, Montreal, P.Q.

restored. Nitrous oxide anaesthesia is maintained until surgery is completed. Suction is applied to chest drains during closure of the thorax so that no pools of blood accumulate.

Complications

The most serious complications of closure of atrial septal defects under hypothermia occur in conjunction with the occlusion period.

Air emboli. Two patients had air bubbles evident in the coronary vessels after occlusion and both hearts fibrillated and required massage. Two others with cerebral disturbances postoperatively were probably due to air emboli. Recovery was complete in all cases. To avoid this complication, carbon dioxide is used, the lungs are inflated for the final suture, and the table is tilted so the defect is at the uppermost part of the left atrium.

Ventricular fibrillation. This complication occurred in eleven patients. Two were associated with air emboli, already mentioned, two with marked blood loss, one with the use of citrated blood for replacement, and one with inferior vena caval obstruction. In the other five patients, the causes were not evident, but there was no direct relation to duration of occlusion. All recovered completely.

Blood loss. Blood loss exceeded 1,000 cc. in five patients for reasons already discussed. Successful replacement was accomplished.

Anatomical difficulties. (*a*) *Diagnostic error*: two patients had an ASD with partially anomalous venous return—closure was successfully accomplished in 6 and 5 minutes respectively; one patient had an ostium primum defect and was closed successfully in 7½ minutes. (*b*) *Multiple defects*: two patients had three defects each, requiring 4 and 7½ minutes respectively and one had two defects requiring 5½ minutes. (*c*) *Dextro-position*: one patient with dextro-position of the heart was technically difficult and required 7½ minutes to repair. (*d*) *Large defect*: in one patient early in the series, digital exploration of the right atrium revealed no lower rim; a repair was not attempted but one year later closure of a secundum defect was successfully accomplished using the cardiac by-pass method; subsequent to this case, all ASD's were visualized and then closed. (*e*) *Incomplete closure*: in only one patient has an incomplete closure been discovered.

Severe arrhythmias occurred in two patients. One patient developed auricular tachycardia 25 minutes after induction while at a temperature of 37.4°C. The heart rate exceeded 260 per minute and the blood pressure fell to 40/0. Deep cyanosis occurred despite full oxygenation, owing to a reversal of the atrial shunt. The tachycardia gradually responded to five doses of 0.1 mg. of Prostigmine over a period of 20 minutes. Operation was cancelled. This patient had had a "blind" Sondergaard procedure two years previously with incomplete closure.

A second patient had a transient period of auricular fibrillation with a ventricular rate of only 40, but recovered promptly. Transient arrhythmias of all types may occur but are especially common when the cavaltapes are placed in position or when the heart is manipulated.

Postoperative complications consisted of cerebral disturbance, in two patients, one lasting 10 days and the other a few hours. One patient developed a small hydropneumothorax, and another developed a mild pneumonia. A late complication occurred in a patient who developed a staphylococcal pericarditis one month postoperatively.

Summary

This paper deals with a total of 63 cases of atrial septal defect with which one author (A.W.C.) was associated. All patients were diagnosed preoperatively as atrial septal defect of the secundum type and surgery was undertaken for direct closure of the defects with the aid of hypothermia. No deaths occurred in the series. The physiopathological disturbances, anaesthetic and hypothermic techniques, and complications are discussed.

Acknowledgments

The inspiration and example set by Drs. J. D. Keith, R. D. Rowe, and W. T. Mustard are gratefully acknowledged.

Résumé

Ce travail contient l'etude de 63 cas de communications interauriculaires auxquels l'auteur prit une part active. Tous les cas furent diagnostiqués préoperativement comme étant des communications interauriculaires de type secondaire et furent dirigés vers la chirurgée pour une fermeture directe de la communication avec l'aide de l'hypothermie. Il n'y a eu aucun décès dans cette série. Les effets physio-pathologiques de la communication, la technique anesthésique, l'hypothermie et les complications sont discutées.

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CARDIAC OUTPUT DETERMINATION IN THE OPERATING ROOM: A MICROTECHNIQUE

DAVID ALLAN, M.B., CH.B., A. W. CONN, M.D., B.SC.(MED.), F.R.C.P.(C), and C. I. JUNKIN, M.B.[1]

THERE HAS BEEN a need for a simple method of cardiac output determination under operating room conditions. A practical method has been evolved. It is an area dye dilution technique after Hamilton (1), employing "Coomassie Blue RL" (AY-58112)[2], and applying the Forward-Triangle Formula of Hetzel (2).

DESCRIPTION

The apparatus used is a Sanborn Oximeter Adapter Box Model 461-160 which couples a Waters Oximeter Control Box Model X70, insulated and modified for dye estimations, to a Sanborn Low Level Preamplifier Model 150-1500, Modification A. The following control settings are applicable:

Waters Oximeter Control Box Model X70 (Modified)

1. Sensitivity at H.S.
2. Blue Dye Sensitivity Control at maximum

Sanborn Low Level Preamplifier Model 150-1500 (Mod. A)

1. Attenuation X I
2. Sensitivity adjusted so that a calibration signal of 40 mμ gives a deflection of 0.7 cm.

Hum and stray potentials are negligible.

Automation can be accomplished successfully with a constant flow system such as the Colson Model 1055 for withdrawal, and two compressed air-firing systems with split-second staggered timing for the injection of dye and flushing solution, interconnected through an appropriate coupler to the remote marker position of the Sanborn system.

As this method is primarily designed for operating room use, a Waters cuvette is employed, but there is no contra-indication to an earpiece oximeter.

The dye selected was Coomassie Blue RL for the following reasons. (i) In the doses employed even on repeated application, there is no clinically observed staining of the patient, in sharp contrast to Evans Blue. (ii) It has a reasonably fast excretion time of four hours. Cardio-green is much more rapidly excreted, but it is open to question whether or not it circulates at least once *in toto*, before leaving the circulation. Therefore it cannot be used for output determination.

Owing to the purity of the dye curves obtained it is not found necessary to rigidly apply a dose/weight relationship. Thus a 1.0 ml. syringe is calibrated in

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[2]Supplied by Ayerst, McKenna & Harrison, Limited, Montreal, P.Q.

only three positions, 0.3 ml., 0.6 ml., and 1.0 ml. For example a 6 mg. dose is satisfactory for a patient weighing up to 30 kg.

Calibration of the Peak Concentration Using Three Standard Solutions

1. Using a calibrated syringe approximately 20 cc. of the patient's blood is placed into each of three bottles containing mixing beads.
2. Then, 20 Landau units of heparin are added.
3. Then, 20, 40, and 60 Landau units of dye are added to the bottles successively.
4. The bottles are vacuumed by withdrawing the air through the rubber stoppers with a syringe. This prevents changes in O_2 saturation.

This interrelationship of three known quantities of dye to known quantities of blood produces three standards of 20 mg./L., 40 mg./L., and 60 mg./L. approximately. On passing the samples through the cuvette, three linear deflections are obtained.

Calculations

The "forward triangle" of Hetzel is the initial portion of the dye curve that is delineated by the peak concentration (C_p) and the build up time (T_B) (see Fig. 1).

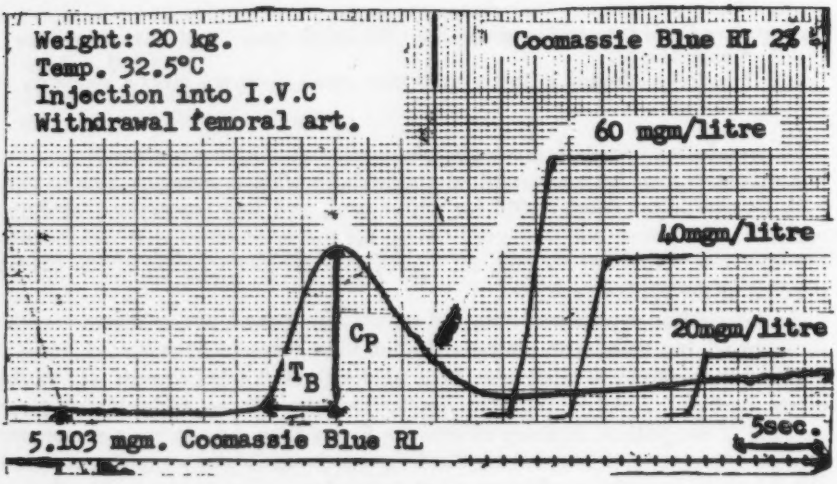

Figure 1. Dye curve.

Forward Triangle Formula:

$$Q = \frac{2K\ 60I}{T_B\ C_P}$$

where Q = cardiac output (L./min.)
K = constant of proportionality (0.37 for central injection)
I = total amount of injected indicator (mg.)
T_B = building up time (sec.)
C_P = peak concentration (mg./l.)

Also, on repeated estimations on the same patient, using a constant dose of dye:

$$\frac{Q_1}{Q_2} = \frac{{}^{T}B_2\,{}^{C}P_2}{{}^{T}B_1\,{}^{C}C_1}$$

where Q_1 = 1st output (L./min.)
${}^{T}B_2$ = 1st build up time (sec).
${}^{C}P_1$ = 1st peak concentration (mg./L.)
Q_2 = 2nd output (L./min.)
${}^{T}B_2$ = 2nd build up time (sec.)
${}^{C}P_2$ = 2nd peak concentration (mg./L.)

Therefore, the effect of variable factors, such as anaesthetic agents, on cardiac output can be readily assessed and compared.

Sources of Error

1. If the oxygen saturation of the patient varies during withdrawal, the base line wanders so that no quantitative estimation can be made.
2. A cardiac catheter of less than size 7 in the arterial side will not consistently give a good withdrawal, especially if the Colson Constant Flow System is used.
3. It is preferable to use central sites and use the figure 0.37 as the constant of proportionality.
4. As this is a microtechnique, care must be exercised in measuring dye doses and dilution of the standards.
5. Practice is necessary to ensure exact timing unless an automated system is used in firing dye and flushing solution.
6. The volume of the arterial catheter in relation to the time-withdrawal cycle must be considered in assessing the efficacy of the curve.
7. This method is not applicable when peripheral or central shunts or regurgitation are present.

Conclusion

A microtechnique for the estimation of cardiac output has been evolved. It is accurate and functional for operating room use.

To a dye dilution area method a simplified formula is applied resulting in cardiac output determination being readily available.

Acknowledgments

The authors wish to thank W. T. Mustard, F.R.C.S.(C), Senior Cardiovascular Surgeon, Hospital for Sick Children, Toronto, and his staff for their co-operation during this study.

They also wish to acknowledge the help, guidance, and encouragement given by R. D. Rowe, M.B., Cardiologist, Hospital for Sick Children, Toronto.

Résumé

La micro-technique pour la determinations du "output" cardiaque a été mise en évidence. Elle est exacte et appropriée pour la salle d'opération. Une méthode

simplifiée de colorimétrie fut employée. Elle nous a permit d'obtenir immédiatement la determination de l'output cardiaque.

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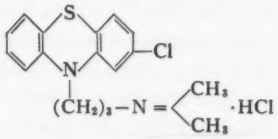
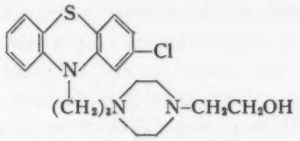
PERPHENAZINE IN CLINICAL ANAESTHESIA[1]

ALLEN B. DOBKIN, M.D.[2]

PERPHENAZINE (Trilafon®) is 1-(2-hydroxyethyl)-4-[3-(2-chloro-10-phenothiazyl)-propyl]-piperazine. The chlorophenothiazine derivative is obtained as a white crystalline solid which is soluble in organic and inorganic acids. It combines with hydrochloric or maleic acid to give crystalline salts which are water soluble. Tablets for oral administration contain 2, 4, and 8 mg. The intramuscular and intravenous preparation is provided in colourless ampoules containing 5 mg. in 1 ml. The pH of this solution is 5.9 and causes no irritation when injected by vein or into the muscles. Perphenazine is one of the "broad spectrum" group of tranquillizers. The structural relationship to chlorpromazine is shown below:



CHLORPROMAZINE (LARGACTIL®)



PERPHENAZINE (TRILAFON®)

Following initial reports of the wide range of neuro- and psycho-sedative effects and the potent anti-emetic activity of perphenazine (1, 2), a preliminary trial was made with this drug in association with anaesthesia. Perphenazine was reported to provide a satisfactory sedative response without excessive hypnosis, and it appeared to be effective in alleviating nausea and vomiting, at a dose level which did not cause a significant change in blood pressure, pulse rate, or respiration (3). A more extensive trial was therefore undertaken to test perphenazine for two specific applications in anaesthesia. Animal studies were carried out to determine whether perphenazine was effective in suppressing epinephrine-provoked cardiac arrhythmias in dogs under anaesthesia (4, 5). Clinical studies were carried out mainly to determine the anti-emetic effects of perphenazine in association with anaesthesia.

METHOD

Those patients with a previous definite unpleasant history of postoperative vomiting were premedicated with perphenazine, usually without a narcotic supplement, and the incidence of postoperative vomiting was recorded. Perphenazine was also administered during the course of regional anaesthesia in patients who required supplementary sedation or relief of hiccoughs, or who developed nausea and vomiting during the operation. Patients who had nausea,

[1]Read at the Annual Meeting of the Western Division of the Canadian Anaesthetists' Society in Saskatoon, March 19, 1959.

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retching, and vomiting in the early postoperative period were treated with perphenazine either intravenously or intramuscularly to determine whether these symptoms could be alleviated immediately while the patient was under direct supervision in the postanaesthetic recovery ward.

The study was set up in this way because many of the patients who were scheduled for major operations were premedicated with other phenothiazine derivatives (promethazine, levomepromazine, promazine, and proclorperazine) which would reduce the incidence of nausea and vomiting postoperatively.

From July, 1956, to October, 1957 (16 months), the over-all incidence of nausea and vomiting among patients admitted to the recovery room, *excluding those who arrived with gastric suction*, was 705 in a total of 4,563 (15.5 per cent). Perphenazine was under trial from November, 1957, to February, 1959 (16 months). During this time the incidence of nausea and vomiting was 818 in a total of 5,383 (15.2 per cent). Aside from the introduction of Fluothane, and Fluothane-ether anaesthesia, there were no remarkable changes in the types of anaesthetics used in the second period.

In the first period, over 14 per cent received a phenothiazine for premedication, while in the second period over 16 per cent received a phenothiazine for premedication. This did not materially affect the data that were analysed, because most of these patients underwent major abdominal operations and gastric suction was used in many of them.

Since it was not desirable to administer additional drugs as a routine prophylactic against symptoms which might require treatment in less than 15 per cent of patients, it was left up to the senior nurses of the recovery room to request treatment for those patients who were having persistent nausea, retching, and vomiting, and to record whether administration of perphenazine intravenously or intramuscularly was effective in relieving the patient promptly. This method was considered valid in handling a situation where the course of the untreated symptom is notoriously variable, and where the trap of *post hoc* reasoning might be fallen into if every patient received the same treatment.

Results

During this trial, 107 patients had a definite previous history of vomiting after general anaesthesia. Perphenazine was used for premedication intramuscularly about one hour before scheduled operation in each of these. Postoperative vomiting occurred in 11 patients of this group (10 per cent).

During the course of regional anaesthesia, 73 patients were given perphenazine 5 mg. intramuscularly or intravenously as supplementary sedation. In each patient the resulting sedation was satisfactory and two of these vomited postoperatively. Perphenazine was administered to 54 patients in whom nausea or vomiting developed during spinal anaesthesia, with prompt and complete relief in all but one. In 233 other patients who received low spinal anaesthesia, nausea and vomiting occurred in 29 (13 per cent). Hiccough was treated only seven times, with prompt relief in six patients.

Persistent nausea, retching, and vomiting was treated in 411 of 818 patients in

the recovery room. Of these, 362 received perphenazine. All but 18 obtained prompt and complete relief (95 per cent effective). The other 49 patients were given a variety of other anti-emetic drugs by choice of the surgeon, and will not be considered here. Many of the patients who were not given specific drug therapy had a long period of vomiting and were treated with gastric suction.

During the period that perphenazine was under trial, it was noted that the onset of nausea and vomiting in the recovery room followed the administration of pain-relieving drugs (meperidine, morphine, and codeine) in 212 patients (26 per cent).

Discussion

Nausea and vomiting are often regarded as a protective function for the removal of noxious substances in the gastro-intestinal tract and an important diagnostic sign. However, the development of these symptoms in the immediate postanaesthetic period serves no apparent useful purpose, and often may be detrimental to the patient. Retching and emesis during this period may increase pain at the operative site, aggravate emotional upsets related to the operation, and, if persistent, may upset water and electrolyte balance. Fear and anxiety associated with vomiting may also rapidly exhaust the postoperative patient.

Many drugs are available to the anaesthetist now which have sedative and anti-emetic activity when used for premedication. It is also thought that with the newer anaesthetic agents, and improvements in technique, the incidence of nausea and vomiting directly related to the effect of anaesthesia itself is in sharp decline. For these reasons, the main part of this study was directed to evaluating the effect of perphenazine on nausea, retching, and vomiting after their development.

It has become apparent that even with the use of a variety of tranquillizing drugs, there are still between 5 and 10 per cent of all postanaesthetic patients who vomit, regardless of the anaesthetic technique. Though the pharmacological and physiological bases for nausea and vomiting have been studied in great detail, the site of action of emetic drugs and other noxious stimuli have not been clearly elucidated (6). When one looks more closely at this problem in the postoperative patient, two etiological factors might appear to emerge more clearly. First and foremost, anxiety and fear might be important causes of vomiting, owing either directly to the cortical and subcortical effects of emotion, or secondarily to the effects of hypotension, due to blood loss, surgical trauma, anaesthetic drugs, or the anxiety itself. Secondly, aside from effects of induction and emergence from anaesthesia (ether especially), the analgesic drugs may cause nausea and vomiting. In over one-quarter of the patients who developed nausea and vomiting postoperatively, the onset followed the administration of a pain-relieving drug. It is highly likely, therefore, that the analgesics themselves act as an emetic stimulus after general anaesthesia. This observation is well known, but is seldom mentioned or considered in reports on prophylactic and therapeutic trials of anti-emetic drugs.

The observation that administration of some of the tranquillizer drugs as preoperative medication or immediately preceding the end of an operation

produced an anti-emetic effect may be explained on the basis of a prolongation of the analgesic and sedative effects of the anaesthetic. This permitted a longer postoperative period of narcosis and "belle indifference." There may also be direct suppression of the medullary emetic trigger zone by such drugs. These mechanisms were considered with chlorpromazine, and probably apply to perphenazine (7–10).

Since it is difficult to estimate a patient's capacity to control his tension and anxiety and to suppress feelings of dependence and helplessness, it is wisest, in most cases, to observe the response to surgical trauma and pain, and treat the complaints and symptoms as they arise, employing only those agents which are proven to be highly effective. Perphenazine relieved nausea, retching, and vomiting in 95 per cent of the patients treated in this study, without causing an undesirable hypnotic effect, or depression of blood pressure or respiration.

Others have reported the efficacy of perphenazine as a postoperative anti-emetic. In a blind study of perphenazine and a placebo, alternate patients were given perphenazine intramuscularly immediately preoperatively and then intramuscularly every 6 hours for 3 doses. The dose selected was 3.75 mg. perphenazine for all patients over 12 years of age, so that each patient received a total of 15 mg. in 18 hours. No alteration was made in the usual routine premedication. They found that the incidence of vomiting was reduced from 18 per cent (placebo) to 6.3 per cent (perphenazine) in a series of over 600 cases. They also found that perphenazine did not cause hypotension or prolonged narcosis (11). In the second study (12), alternate patients in a series of 200 were given 5 mg. of perphenazine intramuscularly at the end of the operation, and they were observed closely for the first 6 hours after operation for incidence of vomiting. These patients were unselected, except that patients with stomach tubes and those scheduled for a gastrectomy were omitted. There was no evident difference between the control and treated group regarding premedication, anaesthetic agent, or operation which might contribute to the vomiting rate. The control group had a vomiting rate of 21 per cent; of those who received perphenazine, 7 per cent vomited in the first 6 hours postoperatively. No side-effects of perphenazine were observed.

The present investigation revealed that premedication with perphenazine reduces the incidence of postoperative vomiting in patients with a previous history of such a disturbance, and it is highly effective in relieving these symptoms when they occur in the operating room during regional anaesthesia. It was 95 per cent effective in relieving nausea, retching, and vomiting without delay in the recovery room. It was also uniformly effective in providing adequate sedation during regional anaesthesia in every case in which it was used as a supplement.

Summary and Conclusions

An evaluation of perphenazine was carried out to test its prophylactic and therapeutic effects on nausea, retching, and vomiting, which occurred during or after anaesthesia.

The prophylactic effect was tried in patients who had a previous history of vomiting after general anaesthesia. Only 10 per cent of these patients vomited postoperatively. When administered as supplementary sedation during spinal anaesthesia, the incidence of postoperative vomiting was much less (2 per cent) than in those who did not receive perphenazine (13 per cent).

Nausea, retching, or vomiting which developed during regional anaesthesia or in the postanaesthetic recovery period was effectively and promptly relieved in 95 per cent of the patients who were treated with perphenazine.

The single administration of 5 mg. perphenazine intramuscularly as premedication, or as supplementary sedation, is effective prophylaxis for reducing the incidence of postoperative nausea and vomiting. The same dose administered intravenously or intramuscularly is highly effective therapy for nausea, retching, and vomiting which develop during regional anaesthesia or after general anaesthesia. This dose has no significant effect on the blood pressure, pulse rate, or respiration.

Acknowledgments

Supplies of perphenazine (Trilafon®) were kindly provided by Dr. W. MacDonald, Schering Corporation, Montreal.

I am very grateful to Miss P. Harvey and her staff in the postanaesthetic recovery room for their conscientious assistance and co-operation during this study.

Résumé

Au cours de l'anesthésie régionale ou à la suite de n'importe quelle anesthésie, l'apparition de nausées, de haut-le-cœur et de vomissements ne présente aucune utilité pour le malade et souvent devient nuisible au malade. Cela augmente la douleur au site opératoire et le stress psychique qui accompagne l'opération et cela peut même troubler l'équilibre hydrique et électrolytique. La crainte et l'anxiété ajoutées aux vomissements peuvent aller jusqu'à épuiser le malade au cours des suites opératoires.

A part l'induction et le réveil de l'anesthésie, la crainte et les agents analgésiques ont été comptés comme des facteurs responsables des nausées et vomissements. A cause de cela, puisqu'il est très difficile de prédire si un malade vomira, il nous semble plus sage, dans la plupart des cas, d'observer la réponse à l'anesthésie, au traumatisme chirurgical, à la douleur et de traiter ensuite les plaintes et les symptômes tels qu'ils se présentent en employant exclusivement les substances qui se sont avérées des plus efficaces.

Nous avons fait une étude de la perphenazine (Trilafon®) pour apprécier ses effets prophylactiques et thérapeutiques des nausées, haut-le-cœur et vomissements observés au cours et après l'anesthésie.

Nous avons étudié le pouvoir prophylactique chez des malades qui présentaient une histoire antérieure de vomissements à la suite d'anesthésie générale. Seulement 10 pour cent de ces malades ont vomi après l'opération. Lorsque nous avons donné de la perphenazine comme sédatif additionnel au cours de la rachianes-

thésie, la fréquence des vomissements post-opératoires a été réduite de beaucoup (2 pour cent) comparativement aux malades qui n'en avaient pas reçu (13 pour cent).

Chez les malades qui, au cours d'une anesthésie régionale ou au cours du réveil de l'anesthésie, présentaient des nausées, des haut-le-cœur et des vomissements, le traitement à la perphenazine a été promptement efficace dans 95 pour cent des cas.

Le seul fait d'administrer 5 mg. de perphenazine par voie intramusculaire en prémédication ou comme sédatif additionnel devient une prophylaxie efficace pour diminuer la fréquence des nausées et des vomissements post-opératoires. Cette même dose donnée par voie endoveineuse ou intramusculaire est un traitement très efficace des nausées, haut-le-cœur et des vomissements qui apparaissent au cours des anesthésies régionales et après l'anesthésie générale. A cette dose, nous n'avons pas noté d'effets appréciables sur la tension artérielle, la vitesse du pouls et la respiration.

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GENERAL ANALGESIA FOR MAJOR SURGERY[1]

RONALD S. LAMBIE, D.A.(ENG.), F.A.C.A.[2]

O magic sleep! O comfortable bird
That broodest o'er the troubled sea of mind
Till it is hush'd and smooth!

John Keats

OVER THE LAST DECADE there has been an increasing tendency to maintain patients in light planes of anaesthesia. In many cases this has been achieved with a sleeping dose of thiopentone sodium, nitrous oxide, and oxygen, a narcotic and a muscle relaxant (1, 2). This paralytic-narcotic technique has had widespread acceptance. Recently several anaesthetists have attempted to lighten the anaesthesia until the patient is in fact only in the stage of analgesia. This short study was made to determine the feasibility of using nitrous oxide as the primary agent to secure adequate analgesia for major surgery.

Harris (3) has stated that deep anaesthesia to a point of depression of the areas of sensory co-ordination exerts a protective action in preventing deleterious reflexes. Yet with our present-day technique of unconscious paralysis there is no knowing what plane of anaesthesia the patient is in without the aid of an electroencephalogram. It is certain that some of these patients are not in surgical anaesthesia, but do well both on the operating table and postoperatively. It is also stated that they can be most unstable in these light planes of anaesthesia. Nosworthy (4) has made the distinction between peripheral quiescence and peripheral supression. He points out that we are not only anaesthetists, but paralytists as well. Although there is skeletal suppression how effective is the management of afferent impulses bombarding the central nervous system, and what of their effects upon the homeostasis of the body? It is inevitable that interest be aroused in the possibility of controlling the patient in the state of analgesia, where the patient feels no pain, enjoys the minimum of central nervous and cardiovascular depression, and reduction of harmful reflex activity.

It is over a hundred years now since John Snow (5) observed the analgesic state produced by diethyl ether. This observation was not applied clinically until Gwathmey and Karsnar (6) used analgesia for short operations during World War I. Gwathmey was so impressed with his experiences that he perfected a balanced combination of ether in oil rectally, with morphine and magnesium sulphate parenterally. But even these successes did not popularize analgesia. Then, with the insistence of the inherent dangers of light anaesthesia, the state of delirium, the ever-present danger of vomiting, and heightened reflexes, the possibilities of analgesia were passed over in preference for the safety of surgical anaesthesia. Both Guedel (7) and Harris (3) have perpetuated this belief and

[1]Presented at the Annual Meeting of the Western Division, Canadian Anaesthetists' Society, Saskatoon, Saskatchewan, March 19, 1959.

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it remained for Artusio (8, 10) to stimulate our interest in analgesia again. It is perhaps best to quote Artusio to demonstrate how he became interested in this problem: "Quite by accident one of my patients responded to the spoken word and indicated complete freedom of pain. From this observation I began systematically to study the attributes of the analgesic state." It is to Artusio that acknowledgment must be made for his accurate clinical and scientific studies of this state.

It is the purpose of this study to describe a technique which is a modification of that of Artusio, but at the same time relying completely on the fundamentals which he has explored.

His method consists of inducing surgical anaesthesia with nitrous oxide and oxygen, and the rapid introduction of ether. He then lightens the patient, by flushing out the bag with oxygen until the patient is in the responsive state. Ether, in a closed circuit, is added to maintain this state. This method has been performed many times successfully, and a modification was deemed necessary only because of the explosive factor. Artusio in a recent article (8) has stressed the point that ether analgesia is not at all times an explosion-free technique.

Method

A study was made of 33 candidates for major surgery, of which 26 were abdominal or pelvic, 2 were mitral commissurotomies, 4 orthopaedic, and 1 radical mastectomy. There were 17 females and 16 males. The eldest was 87 years of age and the youngest 10, the mean being 56.6 years with a standard deviation of 21.6. The mean Physical Status was 2.24 with a standard deviation of 0.60.

Each patient is visited preoperatively and time is taken to explain the details of the pre-operative phase. It is explained to him that he will have an injection one hour prior to surgery and that his mouth will probably feel dry. Upon arrival at the operating room he will be put to sleep by another injection and will remain asleep until the end of the operation. At no time is it explained to him that he will be conscious during the procedure.

During this visit the patient's general disposition is noted. If there is apprehension, further questioning is made as to its cause, and an attempt made to remove it. In some cases the patient is shown how to remove his tension by muscle relaxation. Hypnosis is not used to induce post-hypnotic states for the preoperative and postoperative phases.

Premedication consists of 0.4 mg. of atropine sulphate alone, or a dose of meperidine; 50–100 mg. if he is a young and healthy adult.

After the patient has been positioned on the operating table, great care is taken to insert an 18 B.D. needle on the back of the hand or the forearm where infiltration is unlikely. It is important that a vein is kept open at all times during this technique. It is also an advantage to use a plastic three-way stopcock which allows for transfusion of blood at the same time as the infusion of succinylcholine.

A test dose of 25 mg. of thiopentone is given, followed by a second dose to induce sleep. This latter dose is in the nature of 200 mg. Immediately after this, a transtracheal injection is done using 3 ml. of a 2 per cent solution of lidocaine.

Several coughs ensue, ensuring adequate spread of the local anaesthetic, before complete paralysis occurs with 40 mg. of succinylcholine. Until complete apnoea is produced, the lungs are ventilated with a 50-50 mixture of nitrous oxide and oxygen. The larynx is exposed and lidocaine is again applied before the insertion of a lubricated cuffed endotracheal tube. The tube is taped securely with all connections well aside to leave a clear view of the face. The cuff is inflated just enough to allow positive pressure without a leak. Great attention is paid to procuring topical analgesia of the larynx and that the endotracheal tube is not placed too far down the trachea.

The patient is then ventilated with a 10 L. flow of nitrous oxide and oxygen, with never less than 2 L. of oxygen, until the respiratory excursions return. It may be difficult in this early phase of denitrogenation to obtain the full analgesic properties of this gas. The patient's reaction and amount of movement will indicate the degree of absence of analgesia. It may be necessary to supplement with an intravenous dose of meperidine or to start the infusion of 0.1 per cent succinylcholine to quieten movement of the extremities. It is always wise when the patient is supine to place a strap above the knees.

Before proceeding to the next part it is well to warn the surgeon that verbal contact will be made with the patient. Unless this is done, much consternation may result!

Reference to Table I shows the various characteristics of the analegsic state.

TABLE I

CHARACTERISTICS OF ANALGESIC STAGE

	Stage I		
	Plane 1	Plane 2	Plane 3
AMNESIA	0	xxxx	xxxx
Response to spoken voice	xxxx	xxxx	xxxx→0
Cerebration	xxxx	xxxx	xxxxx→0
Memory for recent events	xxxx	xxxx	xx——→0
Memory for past events	xxxx	xxxx	xxxx→0
Ability to focus eyes	xxxx	xxxx	xx——→0
Ability to distinguish colour	xxxx	xxxx	xx——→0
Taste	xxxx	xxxx	xxxx→0
ANALGESIA	0	xx	xxxx

A useful signpost is to test for the presence of the lash reflex which generally divides Stage 1 from Stage 2. If present, the patient is asked to open his eyes. The degree of alertness is noticed. This establishes that the patient is conscious. Next the method of communication is established. The patient is told to nod his head up and down for "yes" and sideways for "no." The efficiency of the laryngeal analgesia is tested by these manœuvres.

Table I shows in capital letters the two essential points to be considered, namely AMNESIA and ANALGESIA. A pain stimulus is given to the patient and he is then asked "Do you feel comfortable?" If the answer is "yes," plane 3 has been reached. It will also be noticed that in this plane there is total amnesia. The

technique attempts to hold the patient in this plane throughout the operative procedure. For demonstration purposes the further attributes of this level can be elicited by testing for recent and past memory, distinguishing colours, ability to taste, and apparent utter truthfulness!

If the answer is in the negative, adjustment to the nitrous oxide flow is made if possible, or an addition of intravenous meperidine is made.

The "in and out" method is used with the 0.1 per cent infusion of succinylcholine, and the rate is adjusted to produce the required amount of relaxation. It seems that adequate abdominal relaxation can be achieved, even though the neck and facial muscles are spared enough to be capable of movement. This differential relaxation is insufficient for closure of the peritoneum, because of the powerful stimulus created by tension of this structure. It is better to offer complete paralysis while it is being sutured. Respiration is controlled or assisted manually depending on the degree of relaxation produced.

When the operation is completed, 100 per cent oxygen is given in order to remove the nitrous oxide and prevent diffusion hypoxia. The patient is asked to open his mouth whilst suction of mucus is performed. The catheter is then passed down the endotracheal tube and both withdrawn together. Further oxygen is given.

The patient is then asked to take a deep breath, to cough, to swallow, and to lift his head up. After these are performed satisfactorily he is removed from the operating room.

All patients were seen in the postoperative period. All patients were asked what was the last thing they remembered. Was it coming up in the elevator? Was it arriving in the operating room? Was it the needle stick in the arm?

Results

Table II shows that the longest operating time was 4 hours and 30 minutes, the shortest 1 hour with a mean of 1 hour and 52 minutes and a standard deviation of 55 minutes. The maximum thiopentone dose was 400 mg., the least 100 mg. with a mean of 180 mg. and a standard deviation of 77 mg. The maximum succinylcholine dose was 500 mg. and the least 40 mg., the mean was 270 mg. and the standard deviation was 161 mg. In cases 9, 15, 17, and 23, non-depolarizing drugs were used to intubate, but no further muscle relaxant was used.

Operative behaviour was uneventful. There were no hypotensive episodes during induction. Traction reflexes were noted, but the severity of response appeared less than during conventional anaesthesia.

In one patient modified hypotension was produced with thiophanium sulphonate during successful analgesia. The only change needed was a slight reduction in the nitrous oxide percentage. In a few cases only "reverse flows" were needed. For example, in one 38-year-old female undergoing a cholecystectomy an eventual flow of 20 per cent nitrous oxide was required to maintain analgesia. Maintenance flows of 50 per cent nitrous oxide were not uncommon in the geriatric patient.

TABLE II

Operation	Age	Sex	Physical status	Oper. time (hrs.)	Oper. time (min.)	Inducing dose thiopentone (mg.)	Total succinylcholine (mg.)
Mastectomy	53	F	1	4	30	200	200
Fulg. of bladder	53	F	1	2	00	150	340
Fractured hip	70	F	2	2	30	200	40
Fractured hip	83	F	2	1	45	200	40
C.B.D. exploratn	81	M	3	2	00	200	300
Colostomy	49	F	1	1	45	150	250
Amp. of leg	24	M	1	1	30	400	200
Nephrectomy	33	M	1	2	00	150	400
Bowel anastom.	59	F	2	1	00	100	—15C*
Reanast. of gastrect.	46	M	2	1	00	300	500
Lysis of adhesions	46	M	2	1	30	300	550
Oophorectomy	18	F	3	1	00	300	300
Perf. gast. ulcer	20	M	6	1	00	200	250
Bowel resection	86	M	3	3	00	50	40
Gastrectomy	84	F	3	4	00	200	—20C
Bowel resection	77	M	3	1	30	125	40
Gastr. & splenect.	71	M	3	3	30	100	—20C
Evisceration	78	M	7	1	00	—	40
Cholecystomy	60	F	1	1	15	100	200
Rem. abdo. wall mass	73	F	2	1	00	125	40
Cholecystomy	38	F	1	1	45	250	300
Prostatectomy	78	M	2	1	45	100	350
Appendectomy	10	F	6	1	00	—	—20F†
Gastrectomy	75	M	2	2	15	200	400
Meniscectomy	45	F	1	1	00	200	40
Nephrostomy	28	F	2	1	15	75	200
Perf. gast. ulcer	52	M	6	1	15	250	250
Mitral valvotomy	48	M	3	2	00	200	600
Gastrectomy	78	F	3	2	15	—	220
Ovar. cystectomy	69	F	3	3	15	200	500
Mitral valvtomy	42	F	2	2	30	150	300
Perf. gast. ulcer	54	M	6	1	00	125	250
Cholecystomy	87	M	3	1	00	100	150

*C = curare †F = Flaxidil ®

All patients were seen in the postoperative period several times, and all were sent home well. The impression was formed that these patients did better in their convalescence. There were no serious respiratory or cardiac complications. In fact the nursing staff commented on the excellent progress of those cases they anticipated would not do well. It must be clearly emphasized that this was an impression and no detailed investigation was made concerning convalescent time or morbidity.

Every patient was found to have complete amnesia from the moment of injection of the thiopentone, or in the three patients for whom no thiopentone was used, from the moment when the mask was put on the face.

Discussion

It is interesting to speculate why this general analgesia for major surgery has proved satisfactory, especially in the poor risk and geriatric patient, and to consider the possible pharmaco-physiologic reason for its safety.

Magoun (9) reports that the electroencephalogram shows slow patterns during sleep and surgical anaesthesia, whereas in the wakeful and analgesic state fast activity is noticed, from the area of the ascending reticular system. Perhaps in the analgesic state a block occurs somewhere along the thalamocortical connections, without any depression, but probably with activation of the reticular system. The latter plays an important part in the delicate balance between the sympathetic and parasympathetic divisions of the autonomic nervous system. Artusio (10) feels that the absence of harmful reflex activity is dependent upon the delicate balance of the autonomic system; and for this balance the reticular system and cortex must not be depressed.

Hershey, Zweifach and Rovenstine (11) show that anaesthetic agents have a deleterious effect on the peripheral readjustment mechanisms within the capillary bed proper, and in the presence of haemorrhage initiate shock. In analgesia there is minimal central nervous or cardiovascular depression, and it is most unlikely that nitrous oxide has any deleterious effect on the peripheral mechanisms. This stability of the cardiovascular system is important, particularly when there is present an untreated or undiagnosed preoperative reduced blood volume, through recent weight loss, chronic infection, or nutritional deficiencies (12). Heller and Watson (13) in their study found excellent cardiovascular homeostasis during prolonged major surgery.

Little (14) in his scholarly essay on modern balanced anaesthesia has made out a good case that it does not matter how many drugs are used as long as there is an adequate reason for each one. Better still if this balance is achieved with the minimum of drugs in minimal quantities. In this technique only atropine, nitrous oxide, and succinylcholine need be used, in some cases.. Others require inducing thiopentone and small doses of meperidine. The total is never more than five drugs.

Does the advantageous simplicity satisfy the requirements of surgery? Woodbridge (15) in his fascinating article "Changing Concepts concerning Depth of Anaesthesia" prefers that the elements be broken down into four components, sensory, motor, reflex, and mental. In Plane 3 of Stage 1 the sensory component is satisfied by maximum analgesia which is verified by verbal contact. The motor component of muscle relaxation is produced when required, either by succinylcholine infusion or by direct order to the patient to relax his abdominal muscles. The reflex component is satisfied because of the absence of depression. Finally, the mental state is controlled by the preoperative rapport. Total amnesia ensures that there is no psychological trauma.

Another advantage of this technique is that it is non-explosive. This is of particular importance today since there is much electrical equipment being used in modern surgery. Also in wartime, mass casualties must be dealt with in tent or temporary operating rooms.

In mitral commissurotomies it is useful to be able to tell the surgeon that a cerebral embolism has occurred as observed by facial paralysis.

The intermittent use of succinylcholine, by allowing the return of muscle tone, and even muscle movement, will not interfere with the "milking" of the venous return, such as occurs with long-acting muscle relaxants or with conventional

anaesthetic techniques. As soon as the operation is over, the endotracheal tube is removed and the patient is encouraged to move his legs in order to reduce the possibility of phlebothrombosis. He is also ordered to cough to remove any residual atelectasis.

This study would not be complete without mentioning the disadvantages. The analgesic range of nitrous oxide is sometimes found wanting and even with meperidine it is often difficult to keep husky adults in analgesia.

This is not for the inexperienced. The smallest error may result in a wild patient and an even wilder surgeon! Since close observation of the face and of movements of the head is an integral part of this technique, its use is not practical for the patient who is being operated upon in the prone position.

If there is a language barrier, it is difficult to communicate with the patient. Moderate deafness may be overcome by placing the stethoscope in the patient's ears and talking into the bell. Severe deafness is a contraindication.

The sudden removal of analgesic protection can make the patient restless and vocal in the immediate postoperative period, and care must be taken not to oversedate him.

In 1956, Heller and Watson (13) reported a ten-year survey using analgesia in the poor risk patient. They maintained this state by encephalogram monitoring and using the waking pattern as their guide. This apparently was successful in the poor risk case, for even when partial analgesia was offered, that is Plane 2 Stage 1, there was total amnesia. It is felt that since there is 5 per cent or more of abnormal encephalogram tracings in normal people, the use of this monitoring device alone without clinical correlation is to be discouraged. Although the odds are small, there is always the danger of litigation in the patient who says he remembered the operation and felt pain. The encephalogram is an extremely useful tool, but it is felt that complete reliance should not be placed on it to guarantee analgesia.

Schotz (16) used a similar technique for major cardiac and pulmonary surgery, except that he used fixed flows of 50-50 nitrous oxide and oxygen. A few of his patients remembered some part of the operation, felt no pain, but did not seem concerned. They regarded the experience as if it had been a dream.

Santos and Sweet (17) in 1958, using an identical technique, report excellent results in poor risk patients undergoing thoracic surgery, and find there is a relatively shorter and uneventful postoperative course. They point out in this technique the general adaptation syndrome is aided by allowing the patient as full as possible use of his normal physiologic protective mechanisms.

It was astonishing to see analgesia with as little as 20 per cent nitrous oxide. Hyperventilation did not contribute through cerebral hypoxia for the "in and out" use of succinylcholine allowed the patient to breathe on his own.

The heightened suggestibility of this state was noticed and has been reported by Sheiner (18). It is possible that analgesia can be reinforced and suggestion made to alleviate immediate and long-range pain, and to create a cheerful attitude in the convalescence. Marmer (19) has urged that a greater use be made of hypno-analgesia. Further work is needed to measure these factors and their practicability.

In conclusion, this study has proved a useful technique in the management of the poor risk and geriatric patient particularly. In other groups disappointment may be met and it can only be recommended with reservation.

There is no doubt that ether is a more effective analgesic agent and the easier one to handle, but the innocent properties of nitrous oxide stand firm until a non-explosive agent of ether's abilities are found. The few attempts to use Fluothane alone proved disappointing. Promise may be found in the non-explosive azeotropic mixture of ether and Fluothane of Boivin, Hudon, and Jacques (20).

Finally, it must be said that it is exciting and gives a great personal satisfaction to navigate the patient through the operation without wallowing in the deep sea of anaesthesia, but rather to skim across the waves of analgesia.

Summary

The history of the clinical use of analgesia is briefly reviewed. Artusio's technique of ether analgesia is described. A non-explosive modification of his technique is discussed. Thirty-three candidates for major surgery were offered general analgesia. All patients did well postoperatively. The reason for using this technique is discussed, particularly in relation to the management of the geriatric and poor risk patient.

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Résumé

Nous avons fait une revue historique de l'analgésie. Nous avons fait une mention spéciale de l'ouvrage d'Artusio et "The Fundamentals" qu'il a explorée avec l'analgésie à l'éther. Nous avons expliqué ses méthodes et ensuite nous avons expliqué cette technique en détail. La prémédication est très faible. L'induction est faite avec environ 200 mg. de thiopentone suivie d'une paralysie avec 40 mg. de succinylcholine. Avant la paralysie, nous pratiquons une analgésie trans-trachéale. Le tube endotrachéal est fixé fermement. Nous donnons au malade un débit de 10 L. de protoxide et d'oxygène avec une quantité d'oxygène jamais inférieure à deux litres. Lorsque les respirations sont revenues à la normale, la profondeur d'anesthésie est atteinte. Nous demandons au malade d'ouvrir les yeux. Cette question établit l'état de conscience. Nous lui demandons ensuite de tourner sa tête de côté s'il veut dire "non" et de faire un mouvement de tête de haut en bas s'il veut dire "oui." Nous provoquons une douleur et nous lui demandons s'il la ressent. Nous lui donnons de petites doses de mépéridine pour compléter l'analgésie au protoxide si nécessaire. Ce stage III du plan 1 d'analgésie est maintenu au cours de l'opération.

La myorésolution est obtenue par l'emploi d'une solution à 0.1 pour cent de succinylcholine en nous servant de la technique "in and out." Le tableau 2 nous

montre, sur les 33 cas étudiés, l'état physique, l'âge, l'opération et les quantités de thiopentone et de succinylcholine données.

Sur la table d'opération, tous les malades ont bien évolué et ils ont eu leur congé en bon état. Tous ont manifesté une amnésie complète depuis le moment de l'induction.

Au cours de la discussion, nous avons spécifié que, en état d'analgésie, l'homéostase se maintient. N'importe quel degré de relâchement musculaire peut être procuré par le goutte-à-goutte de succinylcholine et, selon la nécessité, la respiration peut être assistée ou contrôlée.

Nous avons éprouvé difficultés avec le groupe des plus jeunes, mais cette technique est recommandée surtout pour les malades âges et les mauvais risques. Nous ne recommandons pas cette façon de procéder aux débutants dans la spécialité.

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ELECTROENCEPHALOGRAPHIC AND ELECTROCARDIOGRAPHIC PATTERNS DURING OPEN HEART OPERATIONS WITH THE USE OF CARDIOPULMONARY BYPASS[1,2]

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SINCE THE EARLY PART OF 1956, various congenital cardiac anomalies have been operated upon at the University of California Medical Center, Los Angeles, using cardiopulmonary bypass. This report discusses certain observations made on 25 patients who underwent cardiac surgery during 1957, with the aid of the Gibbon screen oxygenator. The bypass apparatus, as modified by our surgical team, has been described in another publication (7). During the entire period of anaesthesia, continuous electrocardiographic and electroencephalographic tracings were recorded, while effects of the anaesthetic agent and other variables were carefully noted. Preoperative diagnosis of the majority of patients (18 total) was interventricular septal defect. Other diagnoses were: transposition of the great vessels in two patients and one case of each of the following: bicuspid aortic valve, pulmonary valve and infundibular stenosis, atrial septal defect with anomalous pulmonary veins, atrioventricular communis with other anomalies, and rheumatic mitral stenosis and insufficiency (Table I). Except for the patients with atrial septal defect, operation was performed in all instances as a life-saving measure because of progressive deterioration of the patient.

METHOD

The physical status of each patient was evaluated by the cardiologist and by the anaesthetist. All 25 patients were considered as severe or extremely severe operative risks (Physical Status (P.S.) no. 3 and no. 4). P.S. no. 3 included children who were relatively well developed and who had not been cyanotic or recently in cardiac failure. In this group were eight of the 18 patients with interventricular septal defect. P.S. no. 4 was the classification given to patients who were cyanotic and poorly developed, or who were receiving digitalis therapy at the time of operation (Table II). Five patients in this category were under one year of age, the youngest being 11 days old. Seventeen patients were from one to eight years of age, while three patients were young adults. Angiocardiographic studies, cardiac catheterization data, functional status of the heart, and age were all taken into consideration in evaluating each patient as a surgical risk.

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TABLE I

DIAGNOSES AND PERTINENT DIAGNOSTIC DATA OF 25 CASES OF OPEN HEART SURGERY

Age (yrs.)	Age (mos.)	Diagnosis	Systemic PR.	R.V. PR.	Anaesthetic agent	Result
6		VSD*	90	62	C*	L
6	6	VSD, Multiple	70	50	C	L
1	3	VSD	100	38	C	L
4		VSD	85	89	C	R*
2	2	Atrioventricular communis, pulmonary valve, and infundibular stenosis	80	83	C	L
2	9	VSD	90	55	C	R
	6	VSD, multiple	92	55	C	T*
	11	VSD, multiple	90	60	C	L
6		VSD	84	42	C	L
1		Bicuspid aortic valve	80	59	C	R
15		VSD	130	45	C and E*	L
	2	Transposition, patent ductus arteriosus, bicuspid aortic and pulmonary valve	—	—	C	T
2 wks.		Transposition, patent ductus arteriosus	100	100	C	T
3	3	VSD	112	38	E	L
31		VSD	136	80	E	L
5		VSD	121	98	E	R
2		Pulmonary inf. and valve stenosis	104	98	E and C	R
23		Rheumatic heart disease, mitral stenosis, mitral insufficiency	—	—	E	T
3		VSD	100	60	E	R
5		Total anomalous pulmonary veins drainage	96	35	E	L
2	2	VSD	120	40	E	R
3	7	VSD	80	76	E	L
3	3	VSD	57	34	E	L
2	7	VSD	100	30	E	L
8	4	VSD	110	65	E	L

*VSD = intraventricular defect; C = cyclopropane; E = ether; R = died in recovery room; T = died on table.

Preoperative medication consisted of meperidine, 1 mg./kg. body weight, with appropriate doses of atropine given 90 minutes prior to incision time. In critically ill patients, the dose of meperidine was decreased by 25 per cent, while in children less than one year of age none was given.

With two exceptions, all anaesthetics were administered by the same person (E.M.K.).

Two patients received 100 mg. of thiopental intravenously for induction; in all others, anaesthesia was induced by cyclopropane. In the first 12 patients, cyclopropane served as the sole agent. In 11 patients, after consciousness was lost, ether was started and continued as the only anaesthetic agent for the remainder of the procedure. In two instances, both cyclopropane and ether were employed. Closed circuit carbon dioxide absorption technique was used in all instances. On 12 occasions, intravenous or intramuscular succinylcholine was employed to facilitate endotracheal intubation.

A venous cut-down for the administration of blood and fluids and an arterial cut-down for direct measurement of blood pressure during operation were instituted by the members of the surgical team as soon as an adequate level of general anaesthesia was achieved.

Preoperative electrocardiograms were obtained in all patients, and a continuously monitored record was secured throughout the operative procedure. In

order to ensure a good electrocardiographic tracing during operation and yet avoid the sterile operative field, needle electrodes were placed in each scapular region, thus providing a modified lead I.

Preoperative electroencephalographic tracings were obtained in all instances and the electrical cortical activity was continuously monitored throughout the administration of anaesthesia. These tracings were obtained by the scalp-to-scalp technique, and recorded on seven channels of the clinical Grass electroencephalographic machine; the electrocardiogram was recorded on the eighth channel.

Rectal temperatures of all patients were monitored with a thermister. The actual operation was usually begun 45 minutes to 1 hour after induction of anaesthesia, when all preliminary procedures had been completed. Both anaesthesia and operating times are summarized in Table II.

TABLE II

IMPORTANT FACTORS IN OPEN HEART OPERATIONS

Surgical risk	Cardiac risk	Art.	Operating time	Anaesthesia	Pump time (mins.)
4	4	SC*	4.10	5.20	21
3	2	SC	3.55	5.05	22
3	3	SC	4.30	5.45	21
4	4	SC	4.10	5.20	21
4	4	SC	4.00	5.40	22
4	3	F*	3.10	5.00	23
4	4	F	4.10	5.30	78
4	4	F	3.20	4.45	22
4	2	F	3.40	5.30	20
4	4	F	3.45	5.25	25
3	2	F	4.30	6.40	15
4	4	SC	4.48	6.13	56
4	4	SC	5.50	7.25	68
3	2	SC	4.10	5.50	42
4	4	F	4.50	7.00	23
4	4	F	5.20	6.20	36
4	4	SC	3.55	5.20	36
4	4	F	4.45	5.40	76
3	3	F	4.12	4.50	20
3	3	F	3.40	5.10	36
3	2	F	3.40	5.10	23
4	4	F	3.50	4.55	23
4	2	F	3.40	4.45	12
3	2	F	3.25	4.30	19
4	2	F	3.45	5.00	27

*SC = subclavian; F = femoral.

In all cases, anaesthesia was somewhat deepened just prior to the onset of extracorporeal circulation. No anaesthetics were administered during the actual bypass or immediately after the perfusion period. Minimal amounts of the agent used previously were administered for 2 to 3 minutes at a time, and only if the patient moved head or limb during the closure of the chest. In four instances muscle relaxants were administered through the arterial inflow of the pump when diaphragmatic movements seemed to interfere with the surgical procedure.

The period of the cardiopulmonary bypass averaged 22 to 25 minutes. The duration of extracorporeal circulation was more prolonged during procedures

other than closure of interventricular septal defect. In one instance there were technical difficulties with the pump oxygenator. Heparinization of the patient's blood in preparation for perfusion and administration of protamine after the bypass was handled by the surgical team. The desired pump flow rate was 70 ml./kg. body weight/min. In the first 10 patients, the blood used in the pump oxygenator was kept at room temperature, while in the remaining 15 patients four 250-watt infrared lamps were placed about 8 in. from the oxygenator screen to increase the temperature of the blood to 37° C. Thus, sudden decrease in body temperature during the period of extracorporeal circulation was minimized and rarely decreased more than one degree.

Results and Discussion

Of the 25 patients operated upon, 11 died. Three infants and one extremely ill adult (with diagnosis of mitral stenosis) died in the operating room. The remaining 7 died within a few hours after completion of the operation.

Electrocardiographic Observations

By placing the needle electrodes on each scapular region, a tracing similar to lead I of the standard electrocardiogram was obtained. While the main deflection, such as the P, QRS, T waves, the cardiac rate, and the general electrocardiographic configuration, could be recognized, this single tracing did not permit accurate measurements of the various intervals, such as the PR, QT, QRS, etc. The effects of various phases of the surgical procedure on the electrical activity of the heart were observed, and the diagnostic and prognostic value of the observed electrocardiographic changes was evaluated.

No variation in cardiac signal was correlated with the administration of ether or cyclopropane. Irregularities, such as ventricular ectopic beats, flattening of the T and P waves, and occasional atrioventricular dissociation due to hypoventilation were observed with both agents. Deepening of the anaesthetic level, as routinely done shortly before actual bypass, often improved the electrocardiographic tracing.

Frequent premature ventricular contractions were noted in 21 of the 25 patients when the chest was opened. This was particularly observed with the introduction of large retractors and rib manipulation in the left side of the thorax. In 2 patients, transient ventricular fibrillation was recorded. In 7 patients, P-wave flattening and disappearance, with PR-interval changes and atrioventricular dissociation occurred intermittently. Pericardial incision occasionally produced ectopic beats and P-wave variation. In all 25 patients, palpatation of the heart and insertion of a needle for intraventricular blood sampling produced marked changes which included long runs of ventricular ectopic beats, runs of ventricular tachycardia, and even short episodes of ventricular fibrillation. Atrial manipulation with insertion of the venous cannulae produced premature ventricular contractions and various degrees of heart block in 10 of the patients. In the 2 patients with transposition of the great vessels, coronary artery dissection produced grossly abnormal irreversible electrocardiographic tracings with

severe arrhythmias, dropped beats, and wide QRS complexes. In all other patients, the changes noted were transient, required no therapy, and were unrelated to prognosis. An increased tendency to the occurrence of cardiac abnormalities was noted in those patients with more severe pulmonary hypertension, in infants, and in younger children.

With the onset of cardiopulmonary bypass, ventricular ectopic beats were occasionally seen, but most of the patients developed generally improved electrocardiographic tracing and a slow rate. In most patients this improvement continued during extracorporeal circulation except when the cardiac beat was arrested with potassium, which produced progressive broadening and widening of the QRS complexes and the T waves, followed in seconds to 20 minutes by complete cardiac standstill. With the return of the cardiac beat, wide QRS complexes, broad T waves, and elevated ST segments appeared, with gradual progression to a normal tracing over the next hour.

When perfusion was discontinued, ST-segment elevation was noted in eight patients, possibly indicating some myocardial hypoxia during the cardiopulmonary bypass or in the immediate postperfusion period. In most patients, the electrocardiographic tracing improved during closure of the chest and in the immediate postoperative period. Prognosis was extremely poor for those patients in whom the elctrocardiogram had not returned to normal or had not approached the preoperative configuration.

Electroencephalographic Observations

Multichannel electroencephalographic recording with identical placement of the needle electrodes on the patient's scalp was secured preoperatively, during the surgical procedure, and for postoperative control tracing.

Normal preoperative electroencephalograms were obtained in 19 patients. Four children had abnormal tracings with no signs or symptoms of neurological disease. One child had cerebral palsy and her preoperative electroencephalogram showed focal changes on the right. In one boy with a neonatal head injury, paroxysmal electrical activity was observed preoperatively.

Classical electroencephalographic patterns, as described by Gibbs and Gibbs (6), Faulconer (5), and others (1, 4) for various planes of anaesthesia, were observed and momentarily confirmed by clinical signs. When ether was employed, anaesthesia was maintained in the plane of analgesia in all cases. When cyclopropane was used as the main anaesthetic agent, the depth of anaesthesia was kept at level 2 or 3 of the generally accepted classification (11).

We have not observed the effect of other variables, such as carbon dioxide retention, composition of gases used for aeration of the donor blood during perfusion, or position of the arterial inflow on the configuration of the electroencephalographic pattern (8–10, 12). However, isoelectric patterns of varying duration were recorded in four patients during partial inadvertent occlusion of the superior vena cava by the surgeon. There were no subsequent changes in the postoperative electroencephalographic tracings of these patients and no clinical signs or symptoms of a neurological complication were detected in the recovery period (3).

In seven of the patients on whom cyclopropane was used as the main anaesthetic agent, an extremely slow, rhythmical pattern with relatively high potentials was observed in all leads in the pre-perfusion period (13). It had a gradual onset and ended in the same fashion. It was asynchronous with any particular phase of the operation or with any other activity in the operating room. It was never noted during or after cardiopulmonary bypass. There were no sequelae observed postoperatively in any of these patients except one. This little girl has shown considerable regression in her development. She improved markedly during the first year after operation, but is still somewhat retarded.

In 16 of the 25 patients, patterns consistent with lighter planes of anaesthesia were observed in all leads after various lengths of time allowed for extracorporeal circulation. One patient died in the operating room. At the end of operation, all others had an electroencephalographic record similar to that seen in the awake patient, and upon removal of the endotracheal tube, they were crying and moving about. Twelve had a normal electroencephalographic tracing postoperatively and four developed an abnormal electroencephalogram during the recovery period with evidence of brain damage, but without any other neurological sign or symptom.

Two patients who had an electroencephalographic pattern indicative of normal electrocortical activity before and after cardiopulmonary bypass developed an isoelectric pattern during perfusion. Both of these patients died a few hours after operation.

In three patients an uneventful course was observed prior to the onset of extracorporeal circulation. This was replaced by an isoelectric pattern during perfusion and persisted for a short period after the patients were returned to their own circulation. One patient survived for three weeks, but no postoperative recording was obtained. The other two died in the operating room without having regained consciousness.

One patient had evidence of normal cortical activity before and during extracorporeal circulation, but a marked reduction in frequency and amplitude was observed in the electroencephalographic tracing during the post-perfusion period. There were no changes in her electroencephalogram from the one recorded preoperatively and no clinical evidence of brain damage.

The four infants were considered the poorest risks of all our patients. Their electroencephalographic tracings before onset of extracorporeal circulation showed adequate electrical cortical activity for their age and remained normal during cardiopulmonary bypass. Although the surgeon was able to repair the defects, the electroencephalographic pattern deteriorated when the patients were returned to their own circulation. They all died, either in the operating room or within a few hours of operation.

Identical placement of the needle electrodes on the scalp of all patients was used before operation, during the entire procedure, and for the tracings obtained on all patients ten days to three weeks after operation. The three records were compared. We were interested to ascertain whether certain areas of the brain might be inadequately supplied by oxygenated blood during cardiopulmonary bypass; and if so, whether this could be manifested by focal changes on the

electroencephalogram. In the 25 patients observed by us and discussed in this presentation, all changes in configuration of patterns noted during any phase of the operation occurred in all leads simultaneously.

We have not observed any deterioration of the electrical cortical activity during manipulation of the heart, or during long periods of cardiac arrhythmias, with the exception of prolonged irreversible ventricular fibrillation (2).

Summary and Conclusions

The most frequently occurring irregularities of the cardiac rhythm during 25 operations on the opened heart were sinus tachycardia, ventricular premature contractions, atrioventricular block, and ventricular tachycardia and fibrillation. Other changes noted in the configuration of the electrocardiogram included flattening and/or disappearance of P waves and flattening of T waves. In the majority of the patients, these changes were transient in character, they did not require any drug therapy, and they usually disappeared with temporary interruption or with termination of the surgical procedure.

It was considered a good sign if the configuration of the electrocardiogram, after cessation of the cardiopulmonary bypass, was identical or similar to that observed before perfusion.

Persistence of the electroencephalographic pattern of a light plane of anaesthesia before, during, and afer perfusion was usually consistent with a good prognosis. Reduction, both in potentials and frequency during extracorporeal circulation or after it, usually carried a poor prognosis.

In all instances, changes in electroencephalographic patterns were noted in all leads, thus indicating equal perfusion of all parts of the brain during extracorporeal circulation. We have no explanation as to why electroencephalographic evidence of brain damage developed in four patients postoperatively.

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Résumé

Nous avons obtenu des tracés électroencéphalographiques et électrocardiographiques chez 25 malades subissant des corrections chirurgicales de diverses maladies cardiaques congénitales. Ces opérations ont été faites à l'aide d'une dérivation cardiopulmonaire en employant l'écran oxygénateur de Gibbon.

Les irrégularités du rhythme cardiaque les plus fréquemment observées ont été une tachycardie sinusale, des contractions ventriculaires prématurées, un blocage atrioventriculaire, une tachycardie ventriculaire et une fibrillation. Parmi les autres changements observés sur le tracé, nous avons observé un abaissement et une disparition des ondes P et un abaissement des ondes T. Dans la plupart des cas, ces changements ont été passagers, ils n'ont requis aucune médication et

ils disparaissaient après un arrêt temporaire ou avec la fin de l'opération. Nous avons observé que ces irrégularités survenaient en certains temps opératoires (la mise en place de gros écarteurs et la manipulation des côtes, l'incision du péricarde, la manipulation du cœur et l'introduction d'une aiguille pour échantillonnage de sang et la canulation de veines). Nous avons considéré que le pronostic était bon lorsque le tracé électrocardiographique, après la cessation de la dérivation cardiopulmonaire, était semblable ou se rapprochait de celui que nous avions pris avant l'opération.

Des tracés électroencéphalographiques obtenus avec des électrodes aiguilles placées aux mêmes endroits sur le scalpe des malades avant, pendant et après les opérations ont été comparés. Nous voulions nous assurer si l'apport de sang oxygéné etait adéquat dans certaines zones cérébrales durant la dérivation cardiopulmonaire et, si oui, vérifier si cela pouvait apporter des changements localisés sur le tracé électroencéphalographique. Sur les 25 malades observés et étudiés dans ce travail, tous les changements sur les tracés observés à tous les temps opératoires sont apparus dans toutes les dérivations simultanément. La persistance d'un type de tracé électroencéphalographique comparable à celui d'un plan léger d'anesthésie avant, pendant et après la perfusion était habituellement de bon augure. Une diminution des potentiels et de la fréquence durant la circulation extracorporelle ou après était considérée comme un mauvais pronostic.

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FLUOTHANE IN OBSTETRICAL ANAESTHESIA[1]

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FOR A NEW ANAESTHETIC agent to be acceptable it has to offer some significant advantage over agents which are in current use. There is at present no ideal anaesthetic for obstetrical use and some compromise always has to be made between the needs of the mother and child and those of the obstetrician. The present authors (1) reported on a series of 233 obstetrical deliveries using Fluothane, and stated that "it would appear that it [Fluothane] will eventually become established in most obstetric units because it fulfils a long felt need as a substitute for chloroform." Since then three papers (2, 3, 4) have appeared on the use of the drug in obstetrical anaesthesia and indicate that, while satisfactory anaesthesia can be obtained, undue uterine relaxation is a major disadvantage. These authors advise against its use in this field, with the exception of Dixon and Matheson (4) who add in a footnote that this is being reconsidered.

The present paper presents a series of Fluothane anaesthetics administered over the years 1956 to 1959 in the Department of Obstetrics of the Royal Victoria Hospital, Montreal, and an attempt is made to answer the question, "Does Fluothane have anything to offer the mother, child, or obstetrician as an advantage over the anaesthetics in current use?"

It is felt that to make the results intelligible the type of obstetrical practice in the Royal Victoria Hospital should be noted. The Department manages a yearly average of 3,239 confinements (1948–1957). Of these, approximately half are delivered in two private case-rooms and half in two public case-rooms. The private rooms are served directly by 12 staff anaesthetists on a 24-hour rotational basis, the public ones by 12 resident anaesthetists on a similar basis with staff supervision. In general, in Montreal, most confinements take place in hospital so that a large part of the practice is normal obstetrics. In 1957, for example, the Caesarean section rate was 3.5 per cent, breech deliveries amounted to 3.4 per cent, and the high forceps rate was 0.12 per cent. A five-year survey of forceps deliveries is given in Table I. The foetal and maternal mortality

TABLE I

FIVE-YEAR SURVEY OF FORCEPS DELIVERIES IN THE ROYAL VICTORIA HOSPITAL, MONTREAL

Year	Low-forceps		Mid-forceps		Total confinements
	No.	%	No.	%	
1953	1,267	38.1	193	5.8	3,317
1954	1,188	34.4	238	6.9	3,451
1955	976	29.1	192	5.7	3,348
1956	898	27.6	145	4.5	3,253
1957	842	25.0	170	5.0	3,378

[1]A report from the Department of Anaesthesia of the Royal Victoria Hospital, Montreal, P.Q.

TABLE II

FOETAL AND MATERNAL MORTALITY FOR 1956

	Canada	Quebec	U.S.A.	R.V.H.
Foetal mortality (per 1,000 live births)	35	44		24
Maternal mortality (per 10,000 live births)	6	9	4	5

TABLE III

DISTRIBUTION OF ANAESTHETICS FOR VAGINAL DELIVERIES, 1957 AND 1958

	1957		1958	
	Total	%	Total	%
Nitrous oxide trilene	1,418	54.90	1,553	60.10
Nitrous oxide fluothane	713	27.60	631	24.03
Cyclopropane	83	3.21	67	2.59
Nitrous oxide	163	6.31	186	7.20
Spinal	175	6.78	104	4.02
Epidural	31	1.20	43	1.66
TOTAL	2,583	100.00	2,584	100.00

figures for the hospital compared to the federal and provincial figures are given in Table II.

Table III shows the numbers and types of anaesthetics used in 1957 and 1958 for vaginal deliveries. No anaesthetist was present in about 20 per cent of the cases. Spinal anaesthesia is declining in popularity for vaginal delivery and only 104 were given in 1958 as compared with 1,125 in 1951 although this latter figure includes those given for Caeserean section. As a rule epidural analgesia is used for delivery only when it is induced during the course of labour for pain relief.

It is possible to divide the general anaesthesia into four main categories. First, nitrous oxide and oxygen are given intermittently for the termination of the second stage of labour and the crowning of the head. Secondly, where episiotomy has to be performed, slightly deeper anaesthesia has to be obtained for the incision and analgesia is maintained thereafter. In both of these categories light surgical anaesthesia is induced for the repair of the perineum. Thirdly, for operative delivery, anaesthesia is required which is just deep enough to prevent reflex movement with manipulation and, after delivery, is lightened during repair of the perineum. Fourthly, relatively deep anaesthesia is required for intra-uterine manipulation.

The tendency is to avoid the use of general anaesthesia when labour has been prolonged or difficult, or when a meal has been taken. Patients for general anaesthesia are all given atropine sulphate 0.4 mg. intramuscularly or intravenously before anaesthesia. Sedative premedication is not used deliberately, but frequently 50 mg. or 100 mg. of meperidine with 0.2 mg. to 0.4 mg. hyoscine are given within the preceding 4 hours. In this series Fluothane was used to

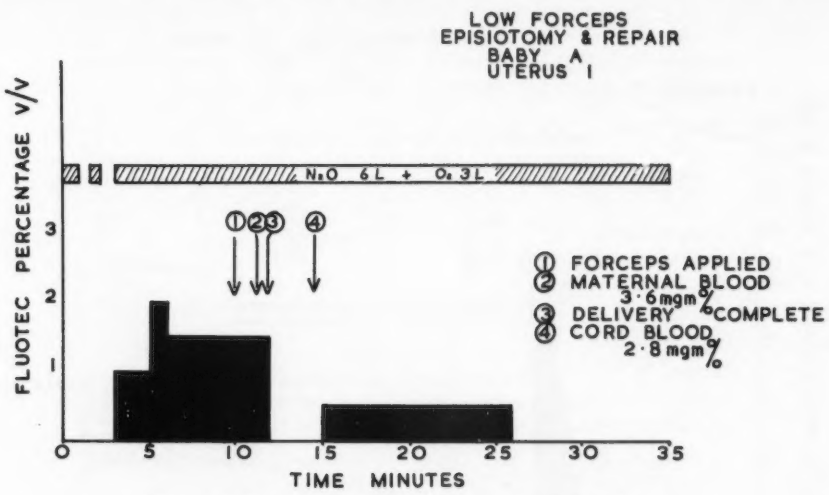

FIGURE 1. Typical low-forceps delivery anaesthetic chart.

supplement nitrous oxide and oxygen anaesthesia in 1,601 instances. A Boyle's type anaesthetic machine with the Magill attachment was used for the administration of Fluothane in the majority of patients, the liquid being placed in the ether bottle. A Fluotec vaporizer was used in conjunction with this machine in the last hundred cases. Gas flow rates of 6 or 7 l. of nitrous oxide and 2 or 3 l. of oxygen per minute were used. Maximum Fluothane concentrations used varied between 2 and 3 per cent by volume of the mixture, this being reached within a few breaths. As soon as the patient was tranquil, the concentration was reduced and Fluothane was discontinued as soon as the baby was delivered. In the typical case the induction to delivery time was 5 or 6 minutes. When the cord was clamped the nitrous oxide/oxygen ratio was increased to 7/2 to take full advantage of this agent and Fluothane was added intermittently to subdue responses. This most usually consisted of giving 1 or 2 per cent of vapour for 1 or 2 minutes. The duration and depth of anaesthesia were varied to meet obstetrical requirements. Figures 1 and 2 show typical administrations. The principle has been to use the minimum concentration of Fluothane for the minimum length of time.

Babies were classified into four categories:

A. Infant breathes and cries within 1 minute and continues to do so as a normal infant should
B. Condition good but not excellent; recovers within 5 minutes to Class A standard
C. Condition fair to poor with moderate anoxia, gasping respiration, and blue congested skin; responds to active resuscitation reaching good condition within 30 minutes
D. Condition serious with severe anoxia and collapse; respiration absent, skin pale and clammy, muscle tone absent, heart beat feeble and irregular; responds only slowly to active resuscitation and condition still not good after 30 minutes
E. Stillborn

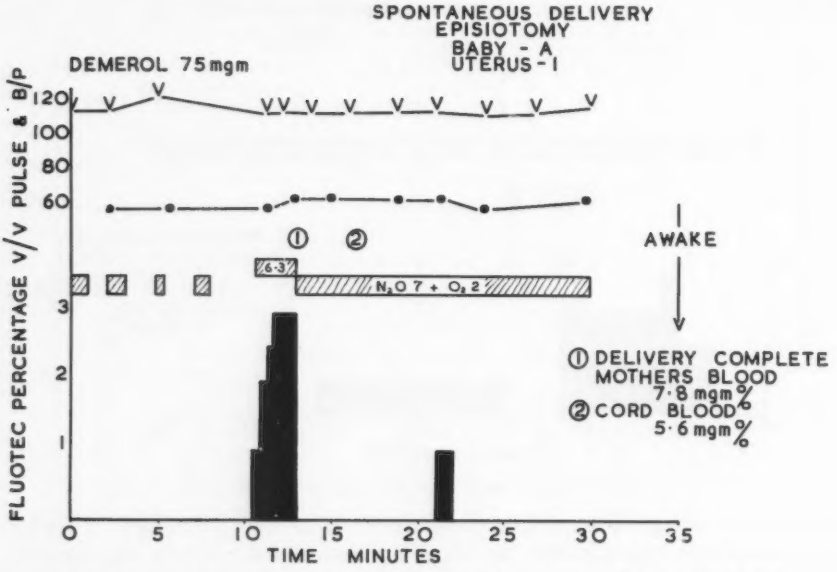

FIGURE 2. Typical spontaneous delivery with episiotomy and repair anaesthetic chart.

We have been unable to trace the author of this scoring system. Class A corresponds fairly closely to the Apgar ratings 8, 9, and 10; Class B corresponds to ratings 5, 6, and 7; Class C to 3 and 4; Class D to 0, 1, and 2.

Uterine tone was assessed as falling into one of three classes. (i) normal uterine tone in the third stage; (ii) other than Class I or Class 3; (iii) frank postpartum haemorrhage (over 500 cc. blood loss).

The concentration of Fluothane in the blood was estimated by the modified method of Duncan (5). Blood from the mother was taken at the moment of delivery, the veins of the back of the warmed hand being used. The concentrations given for the babies are those obtained in the blood of a segment of cord obtained from the obstetrician as soon as was practicable after delivery.

RESULTS

Table IV shows the ratings for the babies, the first part for the whole series of Fluothane anaesthetics, the second part for Fluothane anaesthetics given in 1958; and, for comparison, the ratings for babies born when all other types of anaesthetics were used including spinal and epidural analgesia in 1958. In the whole group of Fluothane anaesthetics the figure of 10.18 per cent for babies rated as B is greater than the figure of 8.53 per cent for the same rating in the control group. This difference is probably significant (chi-square: 5 per cent level). When the 1958 Fluothane ratings are compared to the control group there are no significant differences.

TABLE IV

SCORING FOR BABIES

	N_2O+Fluothane Nov. 1956–Feb. 1959		N_2O+Fluothane 1958		All other anaesthetics 1958 (Control)	
	No.	%	No.	%	No.	%
A	1,396	87.21	491	86.75	1,729	88.80
B	163	10.18*	59	10.43	166	8.53
C	22	1.37	11	1.94	23	1.18
D	5	0.31	0		3	0.15
E	15	0.93	5	0.88	26	1.34
TOTAL	1,601		566		1,947	

*Significantly different from control, $P<0.05$.

TABLE V

SCORING FOR UTERINE TONE

	Nitrous oxide + Fluothane Nov. 1959–Feb. 1959		Nitrous oxide + Fluothane 1958		All other anaesthetics 1958 (Control)	
	No.	%	No.	%	No.	%
1	1,447	90.38*	519	91.70	1,870	96.04
2	130	8.12†	39	6.89†	58	2.98
3	24	1.50*	8	1.41	19	0.98
TOTAL	1,601		566		1,947	
1 & 2	1,577	98.50	558	98.59	1,928	99.02
3	24	1.50	8	1.41	19	0.98
TOTAL	1,601		566		1,947	

*Significantly different from control, $P<0.05$.
†Significantly different from control, $P<0.01$.

TABLE VI

CONCENTRATIONS OF FLUOTHANE IN THE BLOOD OF MOTHERS AND BABIES AT THE TIME OF DELIVERY

Average concentration Fluothane (%)	Time (mins.)	Blood Fluothane (mg./100 ml.)	
		Maternal	Foetal
1 2.0	6	4.0	0
2 1.5	9	3.6	2.8
3 2.0	9	10.5	4.2
4 2.0	5	5.7	2.2
5 2.0	5	6.0	—
6 0.7	17	3.4	—
7 3.0	2	7.8	5.6
8 1.5	3	8.0	4.2
9 1.5	7	9.0	—

Table V shows the ratings for uterine tone when Fluothane was used for anaesthesia: the first part showing the whole series, the second part the series for 1958, and the third part, as a control group, the ratings given with all other types of anaesthetics. A comparison of the whole series of 1,601 patients and the control group shows that more were scored as 2 and 3 in the Fluothane group.

(Significance by chi-square, rating 2—1 per cent level, rating 3—5 per cent level). When the ratings for 1958 are compared to the control group the same differences exist although statistically the difference in rating 2 only is significant (chi-square, 5 per cent level).

Blood concentrations of Fluothane in the mother and child at the time of delivery together with the average concentration of Fluothane administered and the duration of Fluothane anaesthesia are shown in Table VI.

Complications

In this series two patients aspirated some stomach contents when Fluothane was being given and two when trichlorethylene was the anaesthetic. None of these patients had serious sequelae. There were no maternal deaths in the series. In this unit there have been no maternal deaths attributable to anaesthesia since 1946.

Discussion

In setting up this survey in 1956 it was realized that the Apgar (1953) rating for the evaluation of the condition of the newborn approached the ideal. This scoring we believed could not be carried out by the anaesthetist alone with consistent accuracy so that the simpler system was adopted. It appears to afford adequate assessment of the condition of the newborn. The question which we hoped to answer was whether babies born of mothers who are anaesthetized with Fluothane, nitrous oxide, and oxygen are more or less depressed than when other anaesthetics are used. There is a probably significant increase in the number of babies born with a B rating in the whole group of Fluothane anaesthetics. However, the figures for 1958 show no significant differences in any of the ratings.

The part played by general anaesthesia, given to the mother, in depression of the newborn merits some discussion. Many factors are of importance in causing foetal depression and can be classified into maternal and foetal factors, the complications of labour and delivery, and the administration of analgesic drugs. In the absence of any adverse factors, general anaesthesia appears to exert little influence. Smith and Barker (6) showed that in ether anaesthesia no demonstrable depression due to ether exists until the concentration of ether in the umbilical venous blood reached 79.3 mg./100 ml. This concentration would produce surgical anaesthesia. Moreover, they found that resuscitation was required only when the concentration of ether reached 102.8 mg./100 ml. blood. Apgar *et al.* (7) showed that there was no correlation between the concentration of cyclopropane in the foetal blood and the scores of the infant. The figures of Table VI show that when Fluothane was administered in the described fashion an insignificant quantity was to be found in the blood of the umbilical vein. The concentration which produces respiratory depression in the adult (15 mg./100 ml. blood (1)) is quite unlikely to be approached in the baby or in the mother. If deep anaesthesia were to be given to the mother, there is no question that respiratory depression would occur even in an otherwise normal baby. In the earlier part of this series, the tendency was to give deeper anaesthesia and this

probably accounts for the slightly higher incidence of babies scored B in the whole series when compared to the control group. It is of interest to compare the figure of 87.12 per cent for A babies with the strictly comparable figure of 70 per cent for babies scored 8, 9, and 10, that is, those in excellent condition, given by Apgar *et al.* (8). This would indicate that some statistical bias is operative in Dr. Apgar's series, such as general anaesthesia which was deeper or more prolonged, or that heavier sedation was given to the mother. As in all clinical series, statistical bias cannot be considered to be absent from the series shown in Table I; however, we can conclude that with nitrous oxide, oxygen, and Fluothane anaesthesia, no undue respiratory depression of the newborn need be produced.

The over-all reduction in uterine tone after the second stage of labour with the anaesthetic Fluothane requires some comment. This finding is very much in agreement with that of Embrey *et al.* (2) who found that uterine contractions ceased as soon as consciousness was lost when Fluothane was administered. If this uterine relaxation were allowed to persist into the third stage of labour, post-partum haemorrhage would be more likely to occur. The figures at the bottom of Table V show that the incidence of post-partum haemorrhage is not significantly greater in the Fluothane group when compared to the control group (obtained by summing ratings 1 and 2—no post-partum haemorrhage, and comparing with rating 3—post-partum haemorrhage). The important factor in technique appears to be to maintain very light anaesthesia during the third stage of labour. It is necessary to make the comment that the figures for post-partum haemorrhage shown in the hospital report list 162 for 1956, 128 for 1957, and 102 for 1958. These figures are based upon the loss of over 500 cc. blood occurring within 24 hours after delivery and from any site such as cervix, pelvic floor, or uterus; whereas the anaesthetic departmental figures include those only to uterine haemorrhage during the time of the anaesthetist's attendance in the case-room. The controls, however, were assessed in a similar fashion. It is impossible to assess the influence of Fluothane on the over-all figures, but during the years in which Fluothane has been used there has been no rise in the incidence.

We must try to explain why Fluothane is now used by the majority of anaesthetists in the group, in spite of the risk of producing poor uterine contraction in the third stage of labour.

Nitrous oxide, oxygen and trichlorethlyene, and cyclopropane with oxygen are the other most commonly used inhalational anaesthetics in the obstetrical unit so that we are able to make some direct comparisons with these. Fluothane, when used with nitrous oxide and oxygen, allows a very rapid induction of anaesthesia to a sufficient depth to allow the forceps to be applied. If relaxation is required during the course of delivery, this can be produced within a few breaths. There is a striking absence of reflex movement with manipulation when the patient is in very light anaesthesia. This type of movement is most typically seen with trichlorethylene where prevention is often beyond the potency of the agent. Some stridor may occur with manipulation, but laryngospasm has not been noted. This is in direct contrast to cyclopropane anaesthesia in which severe laryngospasm frequently occurs if manipulation is attempted before

surgical anaesthesia has been achieved. There is no stimulation of salivary or bronchial secretions and emergence vomiting is so reliably absent that it is possible to vary the depth of anaesthesia from that necessary for forceps delivery or intra-uterine manipulation to the return of consciousness so that one might attend to the infant if required. It is very doubtful if full surgical anaesthesia with Fluothane is produced in the majority of patients and it appears to be a stage of full analgesia and amnesia from which the patients emerge without vomiting; in which they have reflex protection against regurgitated material; and which allows most of the manipulations of obstetrics. The closest parallel we can offer to this state is that achieved in anaesthesia for general surgery with nitrous oxide, oxygen, and meperidine supplementation. If it were not for this respiratory depression occurring with large doses of meperidine, this would be almost the ideal anaesthetic combination for delivery.

To conclude, Fluothane with nitrous oxide and oxygen forms a very controllable anaesthetic for obstetrical delivery. It should be used in the lowest possible concentration for the shortest possible time. Full surgical anaesthesia with it will produce marked uterine relaxation.

Summary

Between 1956 and 1959, in the Royal Victoria Hospital, Montreal, 1,601 vaginal deliveries have been managed with nitrous oxide, oxygen, and Fluothane anaesthesia.

An attempt has been made to assess the condition of the babies and the uterine tone of mothers receiving this anaesthetic in comparison with a control group. The results show that provided that anaesthesia is maintained in a very light plane, no undue depression of respiration in the babies or of uterine tone in the mothers need be expected.

The place of Fluothane in obstetrical anaesthesia has been discussed.

Acknowledgments

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We wish to thank Dr. Deirdre M. Gillies for the estimation of Fluothane in the blood and Dr. Ming Cheng for her help in the collection of the data.

Résumé

Les tables IV, V et VI nous montrent les résultats de l'adjonction de Fluothane au protoxide d'azote et oxygène au cours de l'anesthésie en obstétrique pour l'accouchement vaginal. Ces tables permettent de faire une camparaison concernant les bébés et le tonus utérin entre le Fluothane et tous les autres anesthésiques donnés comme témoins.

Nous avons partagé les bébés en quatre groupes:

A. L'enfant respire et crie en deçà d'une minute et continue à ce faire tout comme un enfant normal devrait le faire
B. Un bon état mais non excellent; en deçà de 5 minutes, il récupère assez pour entrer dans le groupe A
C. Etat passable à mauvais avec une légère anoxie, il court après son souffle et sa peau est bleutée; il répond aux traitements de resuscitation active au point que, en deçà de 30 minutes, il est en bon état
D. L'état est alarmant avec anoxie sévère et collapsus; il n'y a pas de respiration spontanée, la peau est pâle et moite, une atonie musculaire existe, le cœur bat faiblement et irrégulièrement; il ne répond que lentement à une resuscitation active et, après 30 minutes, on ne peut pas encore dire que l'état est bon
E. Mort-né

Nous n'avons pas réussi à identifier l'auteur de cette classification. Le groupe A équivaut d'assez près à la classification d'Apgar 8, 9 et 10. Le groupe B aux classes 5, 6 et 7 et le groupe C aux 3 et 4. Le groupe D équivaut aux classes O, 1 et 2.

Le tonus utérin a été apprécié et partagé en trois groupes: (i) tonus utérin normal dans le troisième stage; (ii) tout autre que le groupe 1 et 3; (iii) hémorragie post-partum réelle (perte d'au-delà de 500 cc. de sang).

Même au risque de produire une mauvaise contraction utérine au cours du troisième stage de l'accouchement, nous allons essayer d'expliquer pourquoi la plupart des anesthésistes du groupe emploient le Fluothane.

Le protoxide d'azote, oxygène et le trichlorethylène, et le cyclopropane avec oxygène sont les anesthésiques par inhalation le plus fréquemment employés dans notre unité obstétricale de sorte qu'il devient facile de faire une comparaison avec ces procédés. Lorsque le Fluothane est employé avec le protoxide d'azote et l'oxygène, l'induction est très rapide et une telle profondeur d'anesthésie est atteinte qu'il serait possible d'appliquer un forceps. Si, au cours de l'accouchement, on a besoin de relâchement musculaire, on peut l'obtenir en quelques respirations. C'est étonnant comme il existe peu de mouvements réflexes à la suite des manipulations même si la malade est sous anesthésie très légère. Ce genre de mouvements est typique au cours de l'anesthésie au trichlorethylène qui s'avère impuissant à les prévenir. Au cours des manipulations, il arrive d'observer du stridor, mais nous n'avons pas été témoins des laryngospasmes. Cela fait contraste avec l'anesthésie au cyclopropane au cours de laquelle il survient souvent des laryngospasmes importants si l'on tente de faire des manipulations avant d'avoir atteint un plan d'anesthésie chirurgicale. Nous n'observons pas d'augmentation des sécrétions salivaires ou bronchiques et il existe si peu de menaces de vomissements que l'on peut varier la profondeur de l'anesthésie du plan requis pour un forceps ou une manipulation intra-utérine au retour à la conscience ce qui permet, s'il est nécessaire, de prodiguer des soins à l'enfant. Chez la plupart des malades, nous nous demandons si nous produisons une anesthésie chirurgicale complète avec le Fluothane, toutefois nous atteignons un plan d'analgésie et d'amnésie complètes d'où les malades sortent sans vomir, dans lequel ils gardent des réflexes protecteurs contre les régurgitations et qui permet la plupart des manipulations en obstétrique. La parallèle le plus rapproché possible avec cet état est l'anesthésie au protoxide d'azote et oxygène

complétée avec de la mépéridine au cours de l'anesthésie chirurgicale. Si l'on pouvait éviter la dépression respiratoire qui survient avec de grosses doses de mépéridine, cela serait presque l'association idéale pour l'anesthésie obstétricale.

En somme, la Fluothane et le protoxide d'azote et l'oxygène forme un mélange anesthésique facile à contrôler pour les accouchements. Il est préférable de l'employer aux plus faibles concentrations possibles et pour le moins longtemps possible. Une anesthésie chirurgicale complète avec ce mélange va produire une atonie utérine marquée.

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TRIFLUPROMAZINE (VESPRIN®[1]) IN ANAESTHESIA: A CLINICAL EVALUATION

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DURING THE PAST DECADE many new sedative drugs have been introduced into clinical medicine with great success. The concept of tranquillizing action apart from any effects of hypnosis or analgesia has emerged. The term "ataraxia" meaning "calmness untroubled by mental or emotional excitement" was introduced by Fabing (1). Many well-established drugs such as ethyl alcohol, the narcotics, and the barbiturates may produce these effects in addition to their other well-known properties, but are of limited usefulness when only tranquillity is desirable.

TABLE I

DIVISION OF TRANQUILLIZERS
(After Schiele and Benson)

			Dose in mg.		
	Generic name	Trade name	Oral	I.M.	I.V.
Major					
Phenothiazines	Chlorpromazine	Thorazine	50–100	25	5–10
	Promazine	Sparine	100	50	10
	Mepzaine	Pacatal	100	50	25
	Prochlorperazine	Compazine	10	5	
	Perphenazine	Trilafon	10	5–10	5–10
	Trifluprom azine	Vesprin	25–50	20	5
	Promethazine	Phenergan	100	50	
Reserpates	Reserpine	Serpasil	0.25		
	Rescinnamine	Moderil	0.25		
	Deserpidine	Harmonyl	0.25		
Minor					
Alkanediols	Meprobamate	Miltown Equanil	800		
	Phenaglycodol	Ultran	600		
Diphenylmethanes	Hydroxyzine	Atarax	50	25	
	Benactyzine	Suavitil	3–5		
	Azacyclonal	Frenquel	20–100		10

In psychotic states, behaviour-modifying drugs have proved invaluable. Because of the stress and strain of modern living, drugs with a predominantly tranquillizing effect have extensive clinical application. A simple classification of most commonly used tranquillizing drugs is shown in Table I.

[1]Vesprin® is the trade name of trifluprom azine Squibb.

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Drugs of this nature have many advantages and disadvantages. Extensive work has been done in evaluating these compounds under various circumstances and continuing the search for even more satisfactory compounds. Because of their psychic modifying quality and their effects on the autonomic nervous system and the reticulo-activating systems, drugs of this type are of great interest and value to anaesthesiologists. In an excellent review of the efficacy of ataractic drugs in clinical anaesthesia, Dobkin (3) emphasizes the need for evaluating new members of this group of drugs so that knowledge of the efficacy of each agent, coupled with a precise knowledge of its multiple actions and main dangers, may be used in a rational manner to the advantage of the patient and anaesthesiologist.

The phenothiazine derivatives deserve special consideration as drugs of this group, such as chlorpromazine, promethazine, mepazine and promazine, already have an established place in medicine. The phenothiazine compounds have a multiplicity of actions and produce many effects, some desirable and others undersirable, depending on the circumstances of administration.

In a search for more effective and less toxic phenothiazine derivatives with greater specificity of action, Vesprin® was developed by Yale at the Squibb Institute for Medical Research. Vesprin has been given the generic name, trifluprom azine, and chemically is 10-(3-dimethylaminopropyl)-2-(trifluoromethyl) phenothiazine hydrochloride. Its structural formula and that of related compounds is shown in Figure 1.

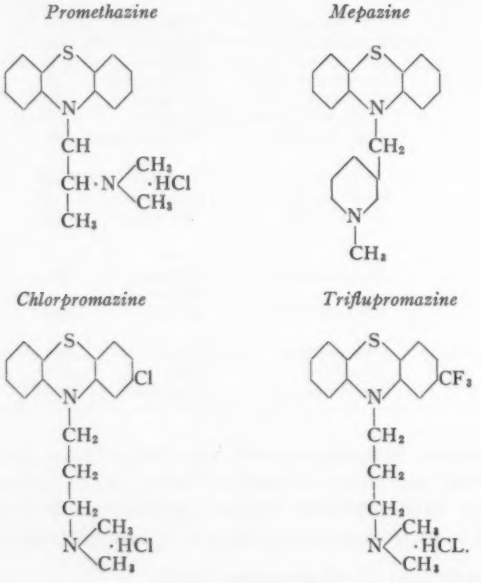

FIGURE 1. Structural formulae of some phenothiazine derivatives.

Pharmacology

Animal

Pharmacological studies in various laboratory animals have shown that trifluprom azine has sedative and depressant effects similar to those of chlorpromazine (in equal doses) but was three to five times as active as a tranquillizing agent and two to three times as potent in inhibiting conditioned response. The anti-emetic activity of trifluprom azine in dogs was from five to ten times greater than that of chlorpromazine. Trifluprom azine produced minimal analgesic effects, but potentiated the analgesic effect of morphine.

Antagonism to amphetamine and lysergic acid diethylamide has been demonstrated but no anti-nicotinic effects. Renal haemodynamics were not affected.

Effects on the autonomic nervous system were similar to those of chlorpromazine but were fewer and less pronounced in that tachycardia was not prolonged following doses of trifluprom azine in clinical range and hypotension was less sustained. The carotid pressor response was blocked and postural hypotension could occur.

Trifluprom azine had a slight anti-parasympathetic activity.

As acute toxicity was similar for the two drugs, trifluprom azine appeared to be relatively more potent than chlorpromazine as a tranquillizing agent, so possessing a greater margin of safety (4–9).

Human

Although accurate inference cannot always be made from the results of experiments with animals, studies on human patients have produced similar results. Adverse effects on hepatic function or on the blood picture were not detected, even after prolonged administration. Hypotensive effects were not troublesome except when doses, now considered excessive, had been given intravenously.

Clinical Reports

Trifluprom azine has been used extensively by many investigators, mainly in psychotic patients, and has been found effective in modifying aggressive and hostile behaviour, in alleviating delusions and hallucinations and for controlling agitation, anxiety, and panic. Behaviour is modified with a minimum of side-effects (10–15). The potent anti-nauseant effect has been confirmed by Stone (16), Westphal (17), and by Adriani (18).

Trifluprom azine has been given in pre-anaesthetic medication to 1,400 children prior to general anaesthesia, and before local anaesthesia to 780 patients by Stone (19); as adjunctive medication to block anaesthesia by Wentzler (20); as an adjunct to obstetrical analgesia during labor by Weber (21); and in control of postoperative nausea and vomiting by Bowman (22). Results, at least satisfactory, have been reported by all of these authors.

Supply

Trifluprομazine (Vesprin®) is at present available as tablets containing 10, 25, and 50 mg. of base (as hydrochloride); as a palatable suspension 10 mg./cc.; and in aqueous solution in 1 cc. ampoules, or 1 cc. rubber-capped vials containing 20 mg./cc. The pH of this solution is 4.1. At pH 6.4 the compound precipitates from solution. Solutions of trifluprομazine are not physically compatible with barbiturate solutions such as thiopentone or pentobarbital, but can be mixed with meperidine, other phenothiazine compounds, and all commonly used intravenous fluids.

Present Clinical Study

As an adjunct in anaesthesiology we have administered trifluprομazine to 1,577 patients (Table II).

TABLE II

Anaesthesia	I.M.	I.V.	Total
Local	638	17	655
General	702	23	725
Spinal	128	39	167
Postoperatively		30	30
Total	1,468	109	1,577

Local Effects

Although all phenothiazine compounds can be irritating to tissues, no local reaction has been noticed nor have complaints of prolonged soreness followed intramuscular injection. After intravenous administration, even when undiluted, no phlebothrombosis has been observed and no complaints of pain following injection have been noted.

Dosage

Trifluprομazine was given as pre-anaesthetic medication alone or in combination with meperidine, pentobarbital, atropine, or scopolamine to a series of 1,468 patients. An additional 79 patients received trifluprομazine intravenously during anaesthesia, and 30 patients intravenous trifluprομazine post-operatively after general anaesthesia.

The preoperative evaluation of the patients revealed many abnormal conditions including cardiovascular, pulmonary, metabolic, hepatic, renal and neurological complications. The observations made with each of the three groups of patients follow.

General Anaesthesia

There were 725 patients ranging in age from 3½ months to 87 years, 368 being children under 14 years. Weight ranged from 15½ to 247 lb. The patients were about equally divided as to sex.

The usual *intramuscular* dose of trifluprομazine (Vesprin®) in adults was 20 mg., but elderly or debilitated persons were given half this amount. Early in the series children were given 1 mg. per year of age but later, as children need

relatively more sedation than adults and tolerate triflupromazine well, children under 5 years of age were given 5 mg., those 5 to 10 years old 10 mg., and those older than 10 were given the adult dose. The *intravenous* dose was originally one-half the intramuscular dose, but when it was realized that almost maximum benefit with far less undesired effects could be obtained by even smaller doses, it was changed to the present dose of 5 to 7½ mg. for adults; 2–3 mg. for children age 7 to 14; and 1–2 mg. for children under 7 years of age. This concept is being further investigated (see discussion). The most effective tranquillization appears 45 to 60 minutes after an intramuscular dose or 3 to 5 minutes after an intravenous dose.

All common operative procedures were represented in the series, including 20 intracranial, 19 intrathoracic, and 10 intracardiac operations. There was no selection of patients and many of the patients were considered "poor risks."

When triflupromazine was given alone, patients became calm but not drowsy or euphoric. Little analgesia was noted. When meperidine (dosage 50–75 mg. for adults; 0.5 mg./lb. to children) was given as well as triflupromazine sedation was better, in that patients were tranquil and drowsy but readily roused. Patients were co-operative, but without excitement, especially of the barbiturate type. A few were asleep when left undisturbed but awoke readily. Most rested peacefully and although alert mentally appeared to be unusually calm in the acceptance of their surroundings. Combination therapy was particularly beneficial in apprehensive children, in whom it is often difficult to attain sedation without depression. These children would tolerate venipuncture with unusual equanimity.

Sedation was considered unsatisfactory in 31 patients (4.4 per cent). Most of these were children who had received triflupromazine alone according to the original smaller dose schedule. Excitement was rarely seen, even with open-drop ether anaesthesia induction. No respiratory or cardiovascular depression was seen, even in elderly patients. An occasional mild tachycardia was noted in a few patients, but this reverted to a normal rate after general anaesthesia was induced.

Salivary secretions were generally reduced when triflupromazine was given alone although the mouth was not completely dry. Usual or reduced doses of atropine or scopolamine, in addition, were effective in controlling secretions during subsequent anaesthesia.

Potentiation of meperidine was apparent. Barbiturates such as pentobarbital and thiopentone were potentiated to a lesser extent and although subsequent anaesthesia tended to be smoother than usual it was felt that anaesthetic agents such as ether, cyclopropane, nitrous oxide, or Fluothane were not potentiated.

Postoperative reflexes returned as usual, but less analgesics were required for control of pain for six to eight hours postoperatively.

A complete record of postoperative nausea and vomiting was not kept for these patients, but it was felt that the incidence was reduced, particularly in children following operation for removal of tonsils and adenoids.

In the recovery room triflupromazine was administered intravenously to 17 adults and 13 children suffering from nausea and vomiting following general anaesthesia. All of the children and 15 of the adults were completely relieved.

Good sedation was also obtained and no hypotension or states of semi-consciousness were seen when the smaller intravenous doses were not exceeded.

Trifluprómazine greatly facilitated cooling in three patients when a hypothermic technique was employed.

Local Anaesthesia

There were 638 patients (ages 17 to 87 years) undergoing ophthalmic surgery. Of these, 469 were operated on for cataract extraction. Trifluprómazine (20 mg.) was usually given intramuscularly at bedtime the previous night; 487 of the 507 patients so treated slept well during the night before surgery. One hour before surgery, 20 mg. of trifluprómazine were given with meperidine (35 to 100 mg.) and in younger or apprehensive patients pentobarbital (25 to 100 mg.).

It was found that the effect of combinations of these drugs gave better sedation than when used alone. Sedation was usually excellent. A typical patient was relaxed and drowsy, neither excited nor euphoric, co-operative during the surgical procedure, obeying and remembering instructions. The analgesia produced by meperidine provided relief from the slight pain and discomfort of the initial injection of the modified Von Lint infiltration.

There was no respiratory depression, but in view of possible hypotension, blood pressure was carefully recorded in 150 patients before medication was given and compared with pressures found after premedication and followed for six hours postoperatively and the next day.

A drop of 25 per cent or more was found in 29 patients (19.3 per cent). Of these 14 occurred before, 13 during, and 2 after surgery.

Initially great concern was felt as possible deleterious effects from the hypotension were anticipated. However, as no ill effects had been observed during a comparable group of patients receiving similar premedication previously, it was assumed that the vital organs were protected by vasodilation maintaining normal blood flow, in spite of the hypotension. This hypothesis was suggested by Buxton-Hopkins (23) and by Lear (24) during work on chlorpromazine. No active therapy was instituted, the pressure returning to normal limits in four to six hours.

Hypotension in other patients (not in this particular series) responded to vasopressors such as methoxamine and desoxyephedrine in doses of 2–5 mg. intravenously and/or 5–15 mg. intramuscularly. The response was more prompt and sustained with desoxyephedrine than with methoxamine, suggesting that trifluprómazine may have some indirect cardiac effect in addition to the vasodilatation.

It was thought that the combination with meperidine was mainly responsible for producing hypotension. A series of patients in a similar age group undergoing transurethral prostatic surgery was premedicated with meperidine alone or with trifluprómazine only. The incidence of fall of blood pressure of over 25 per cent of initial values was 8.3 per cent with trifluprómazine and 18.5 per cent with meperidine.

Subsequently, reducing the dose of meperidine in elderly or hypertensive

patients greatly reduced the incidence and severity of hypotension in this series.

Of the patients undergoing cataract surgery, 4.05 per cent were nauseated and vomited during the postoperative period after receiving trifluprom azine, compared with 13.7 per cent of those receiving the meperidine-pentobarbital combination with no trifluprom azine; and 10.0 per cent of those receiving the usual premedication but with promethazine added.

This reduced incidence of nausea and vomiting was found to be statistically highly significant ($\chi^2 = 19.75$; $p = < .001$).

So pleased and enthusiastic were the ophthalmic surgeons about the usefulness of trifluprom azine in premedication that this series is being made the basis of a separate and detailed report.

Seventeen patients received intravenous trifluprom azine for supplementary sedation during various general surgical operations under local anaesthesia. Sedation was good in all cases and it was found that adequate sedation with minimal hypotensive effects could be obtained with doses of 5 mg. with an additional one or two doses of 2.5 mg. if necessary. The only falls of blood pressure greater than 25 per cent were seen early in the series when excessive doses of 20 mg. had been given intravenously.

Spinal Anaesthesia (181 patients)

An intravenous injection 5–10 mg. trifluprom azine produced a marked sedative and quieting effect with no change in blood pressure or pulse rate in 39 patients who became apprehensive during surgery under spinal anaesthesia.

Trifluprom azine (20 mg. intramuscularly) was given 1 hour before surgery to 142 patients, 120 of these receiving this drug alone. Sedation was good but not so striking as in apprehensive children. Hypotension, particularly postural, was watched for as the patients sat for lumbar puncture. A drop of over 29 mm. Hg occurred in 21 patients, with a drop greater than 25 per cent of initial value in 10 (8.3 per cent), while 5 patients fainted on sitting, 4 with hypotension. All patients who fainted had been sitting upright for 12 minutes.

No exaggerated hypotension followed the onset of spinal anaesthesia and vasopressors in usual dosage when used prophylactically or therapeutically produced the expected response.

Possible Complications

Untoward effects. Three patients developed skin rashes postoperatively. Two were considered to be penicillin reactions and one an urticarial type of blood transfusion reaction. None of these reactions was considered the result of trifluprom azine.

Two patients, ages 85 and 79 respectively, developed cerebral thrombosis after cataract surgery. As both patients were known to be suffering from arteriosclerotic hypertensive cardiovascular disease, and hypotension was not present following the administration of trifluprom azine, this drug was not considered contributory.

Agranulocytosis or extrapyramidal hyperactivity were not seen. No clinical evidence of renal or hepatic toxicity was noted in this series.

Discussion

Whatever one's opinion may be regarding the usefulness and indications for using ataractic drugs in anaesthesiology, it must be agreed that new, powerful and interesting drugs have been added to the anaesthesiologists's armamentarium.

In this clinical study it was convenient to compare the effects of triflupromazine with those of chlorpromazine or promazine which are the best-known phenothiazine derivatives.

It was found that less somnolence was produced but better psychic sedation and tranquillity, co-operation being particularly marked during venipuncture or operation under local anaesthesia. No tissue irritation was seen. A consistency of effects and predictability of action were noted for six to eight hours. The incidence of nausea and vomiting was significantly reduced when evaluated in ophthalmic surgery. The incidence of hypotension was not great or of severe degree and can probably be reduced to an insignificant level by reducing the amounts of narcotics administered simultaneously, and by using relatively small but effective doses of triflupromazine.

The concept of "sub-toxic" doses is emerging. Is it possible to arrive at a particular dose of a specific drug that will give maximum beneficial effects with minimal undesired effects? In the case of phenothiazine compounds it is likely that this can be attained by selective synthesis. Chlorpromazine has a multiplicity of actions, some good, some bad, depending on the circumstances for which it is given. In the case of triflupromazine it is hoped that one can arrive at a dosage schedule that will give very good tranquillization without appreciably lowering the level of consciousness; a profound anti-nauseant effect with little effect on the cardiovascular system. Under different circumstances one's opinion on which are desirable or undesirable effects would be different.

Investigation along these lines regarding both intramuscular and intravenous doses is continuing.

Conclusion

Triflupromazine (Vesprin®), a phenothiazine derivative, appears to be a very useful drug in pre-anaesthetic medication.

It is a potent anti-nauseant; psychic sedation is good; and clouding of consciousness and hypotensive effects are minimal.

Summary

Tranquillizing drugs are of great interest to anaesthesiologists. The investigation of new compounds continues in the hope of finding even more satisfactory agents.

The pharmacology of triflupromazine is briefly reviewed and also the clinical findings of other investigators.

This report deals with the clinical findings after giving triflupromazine to 1,577 patients (postoperatively, 30; pre-anaesthetic–local 655, general 725, spinal 167).

Favourable effects including good psychic sedation without mental clouding; significant decrease in postoperative nausea and vomiting; moderate potentiation of narcotics; slight potentiation of barbiturates, minimal potentiation of anaesthetic agents; no respiratory depression or evidence of toxicity to the renal, hepatic or haemopoietic systems.

Better sedation is attained by combination with small amounts of meperidine and/or pentobarbital. Side-effects are minimal if dosage of all agents is chosen with care. Such combinations are considered very satisfactory prior to local analgesia.

Though some hypotension was seen, its incidence and severity can be minimized by careful selection of dosage.

Further investigation of this agent is considered desirable.

RÉSUMÉ

Les substances tranquillisantes sont d'un grand intérêt pour les anesthésiologues. La recherche de nouveaux produits se poursuit dans l'espoir de trouver des médicaments plus satisfaisants.

Nous avons étudié brièvement la pharmacologie de triflupromazine (Vesprin®) les résultats cliniques d'autres chercheurs.

Ce travail présente les résultats cliniques de l'usage de triflupromazine chez 1,577 malades (dont 30 cas après l'opération et, avant l'opération, 655 cas de locale, 725 de générale et 167 de rachidienne).

Nous avons observé, parmi les effets désirables, un calme psychique sans obnubilation mentale; une diminution appréciable des nausées et vomissements post-opératoires; une potentialisation légère des narcotiques, de même qu'une potentialisation légère des barbituriques et une potentialisation moindre des agents anesthésiques; aucune dépression respiratoire, aucune manifestation de toxicité sur le rein, le foie ou le système hémopoïtique.

On obtient une meilleure sédation si on l'associe au mepéridine ou au pentobarbital. Les effets indésirables sont réduits si l'on choisit le dosage avec soin. Avant l'anesthésie locale, ces mélanges donnent de bons résultats.

En déprit du fait que nous avons observé des cas d'hypotension, cette hypotension peut être raréfiée et moins sévère si l'on choisit bien le dosage.

Il s'impose de faire de plus amples recherches sur cette substance.

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INDICATIONS FOR THE USE OF FLUIDS AND BLOOD BEFORE AND DURING OPERATION[1]

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THE RESPONSIBILITY of the anaesthesiologist should not begin in the operating room. He should visit the patient preoperatively, review the medical history, and carry out a thorough examination if he deems it advisable. This preliminary visit of the anaesthesiologist to the patient has many facets and is most helpful in determining the need for fluids and blood.

In this presentation we are concerned primarily with three aspects of the use of fluids and blood transfusions. They are (i) the special indications for use of fluids and certain drugs before and during operation, (ii) the indications for blood transfusions during the same two periods with comments on the emergency use of substitutes and transfusion reactions, and (iii) practical hints concerning supportive measures.

FLUIDS AND CERTAIN DRUGS

The medical record plus the physical examination of the patient will reveal much information about the status of hydration and the blood electrolytes of the patient before operation. This is important as shown for instance in the recent reports of Keating and Tang (1) on neostigmine-resistant apnoea in the presence of hypokalaemia and the report of Foster (2) who presented evidence for a possible central action of curare with low levels of serum potassium in patients.

Vomiting, protracted diarrhoea, gastric or intestinal suction, gastro-intestinal fistulas, unusual sweating, and burns are frequently accompanied by disturbances in the volume of the body fluids and with changes in the ion composition of the blood. Cardiac failure, cirrhosis of the liver with ascites, and renal insufficiency often also cause imbalances of the body fluids and blood electrolytes. Diseases of the endocrine glands especially are associated with disturbances of the body fluids and electrolytes. Diabetes mellitus and adrenal insufficiency are of major importance. All these conditions demand appropriate treatment. We shall restrict our discussion, however, to diabetes mellitus, adrenal insufficiency, water requirements of children after cardiac operations, and the changes associated with general anaesthesia.

Diabetes Mellitus

The surgical risk for patients with diabetes mellitus is not much increased if proper precautionary measures are taken. The blood sugar of any diabetic

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patient should be checked before the operation, and no diabetic patient should undergo elective surgery unless his diabetes is under control. If a patient ordinarily takes a hypoglycaemic drug by mouth, administration of the drug should be discontinued, and the patient should be given insulin until he recovers from the operation which may require several days. Administration of insulin then may be discontinued, and oral medication may be started if the patient particularly requests it and his condition will tolerate it.

At the Mayo Clinic if possible all diabetic patients are scheduled for operation early in the morning. They receive a third to a half of the dose of their particular type of insulin on the morning of the operation. Breakfast is withheld. During the operation the patients receive by intravenous drip a 0.9 per cent solution of sodium chloride, or if sodium chloride is contraindicated, 5 per cent solution of glucose in distilled water. When 1,000 cc. of the 5 per cent solution of glucose is given, 10 units of regular insulin is added. Before the intravenous drip of 5 per cent glucose solution is started in the operating room, a sample of blood is withdrawn to determine the fasting level of the blood sugar. If administration of the glucose has been started inadvertently before the sample of blood has been taken, blood should be taken from another vein or preferably from another extremity to avoid faulty determinations of blood sugar due to glucose in the needle or in the particular vein used. If the patients receive only the 0.9 per cent solution of sodium chloride, blood is withdrawn for a determination of blood sugar 1 hour after operation. These determinations of blood sugar and the concentration of sugar and ketone bodies excreted in the urine postoperatively serve as a guide for the insulin requirements of the patient for the balance of the day.

If the patient does not regain consciousness as quickly as one would expect or if he reacts otherwise abnormally in the immediate postoperative period, hypoglycaemia must be suspected. A determination of blood sugar quickly establishes this possibility. The appropriate treatment is intravenous administration of glucose to combat this complication.

Adrenal Insufficiency

Adrenal insufficiency due to organic diseases of the adrenal cortex or the pituitary gland, or to suppression of adrenal function resulting from treatment with cortisone or similar compounds, presents special problems for the anaesthesiologist. An adrenal crisis may develop during the operation or during the postoperative period. When a patient has received cortisone or a similar compound in a physiological or larger dose for five to six days, one should assume that a significant suppression of the adrenal cortical function has taken place. Physiological doses of the commonly used steroid medicaments are: 25 mg. of cortisone daily, 20 mg. of hydrocortisone daily, or 5 mg. of prednisone daily. The suppression of the adrenal cortical function may last three to four weeks after administration of these medicaments has ceased. It is wise, however, to prepare patients for operation with parenteral administrations of cortisone if they have received suppressive doses of cortisone within six to eight weeks prior to operation. The cortisone is given intramuscularly in doses of 200 mg. one to two days

prior to operation and on the morning of the operation. During the operation the patient receives a 0.9 per cent solution of sodium chloride intravenously.

If the dose of cortisone which the patient received prior to the planned operation does not warrant preparation of the patient with cortisone, that is, if he received less than a physiological dose or if the interval between the last administration of cortisone and the operation is more than eight weeks, then certain other precautions are taken. The 0.9 per cent solution of sodium chloride is given intravenously during the operation. In case of impending or true shock, 100 mg. of hydrocortisone in 1,000 cc. of 0.9 per cent solution of sodium chloride is given intravenously. This solution is run in at a rate to provide 15 mg. of hydrocortisone or more per hour. The patient should be treated like a patient in adrenal crisis.

If the patient who has received suppressive doses of cortisone withstands the operation uneventfully, there is no need for a tapering-off of the cortisone medication postoperatively, but the blood pressure and pulse rate must be checked every 30 minutes for the first 24 hours after operation. The tapering-off, however, is imperative in that group of patients who suffer from adrenal insufficiency due to organic disease of the adrenal cortex or the pituitary gland. For such patients the dose of cortisone is diminished day by day until the patient's maintenance dose is reached (3).

Water Requirements of Children after Cardiac Operations

Sturtz and co-workers (4) found that 500 cc. of 5 per cent solution of glucose in water per square meter of body surface for the first postoperative day and 750 cc. on each of the second and third postoperative days kept patients in a near zero water balance, provided there was no unexpected loss of fluid. If there was abnormal loss of fluid, their patients were in negative water balance, which the authors thought most desirable for the days immediately after operation. They estimated the water balance by daily changes of the patient's body weight. They found this the simplest and most accurate clinical means of assessing the water requirements.

General Anaesthesia

The effect of general anaesthetic agents plus the stress of the operation will produce an increased secretion of the adrenal hormones. These hormones will cause increased retention of sodium and water and increased loss of potassium by renal excretion. The posterior lobe of the pituitary gland is stimulated and releases antidiuretic hormone. This hormone leads to a further retention of water. These factors associated with general anaesthesia explain the postoperative retention of water. The anaesthesiologist, therefore, should restrict the administration of fluids according to the loss of fluids.

Unless other methods are indicated, all patients who undergo major surgical procedures at the Mayo Clinic are given 5 per cent solutions of glucose in distilled water or in 0.2 per cent solution of sodium chloride. Postoperatively the fluid intake is guided by the patient's output and by changes in the patient's weight. If protracted intravenous administration of fluids is indicated, atten-

tion must be paid to the plasma electrolytes. The potassium level, for instance, is elevated during the day of the operation and from the second day on it is decreased. If the patient needs prolonged intravenous therapy because he is unable to take fluid by mouth, then the serum potassium level should be checked. If the renal output is adequate and if the serum potassium level is low, then potassium should be given intravenously. Potassium can be given as potassium chloride or phosphate. It is given in doses of 40 to 80 mEq. per day. Not more than 40 mEq. are given per litre at a rate of about 500 cc. per hour.

Blood Transfusions

Many physicians have an ever-increasing concern about the number of transfusions being administered to patients in Canada and the United States. Unfortunately, at times it seems that unnecessary transfusions of blood are being given. Recently we heard of a transfusion being administered before the patient left the hospital only because the patient had a credit of 1 pint (500 c.c.) in the blood bank. Of course, this is the extreme example. In 1956, nearly 5,000,000 transfusions were administered in the United States. This number seems to be increasing faster than the population increases. A real indication should be present before blood is requested for a patient.

Not infrequently the anaesthesiologist at the time of his preoperative visit to the patient may need to request some laboratory tests and, on occasion, blood transfusions, or he may request that blood be cross-matched in anticipation of needing it during the operative procedure.

The three principal purposes for transfusion of whole citrated blood to patients anticipating or undergoing a surgical procedure are to increase (i) the oxygen-carrying power of the blood, (ii) the volume of the circulating blood, and (iii) the protein content of blood.

To Increase the Oxygen-Carrying Power of the Blood

Transfusions for this purpose are indicated for patients who have reduced values for haemoglobin and erythrocytes in the blood as in conditions such as acute and chronic anaemia, severe haemorrhage, certain blood dyscrasias or defective formation of blood. It is good practice to provide transfusions of whole blood for patients who are in need of more haemoglobin and erythrocytes when their physiological mechanism cannot produce these two products or cannot produce them soon enough. This is particularly true when the patient is seriously ill or is being prepared for operation.

Certain extremely anaemic persons, who have erythropaenia as well as a deficiency of haemoglobin, normally experience some difficulty in breathing. This difficulty will be increased when the patients are under the exertion associated with anaesthesia and operation if the anaemia is not corrected preoperatively. For such patients transfusions of whole blood are indicated.

To Increase the Volume of Circulating Blood

The maintenance of proper blood volume depends to a large degree on an adequate reserve of fluids in the tissues. Therefore, the correction of a state of

dehydration, anaemia, or hypoproteinaemia is of real importance. A reduction in the volume of circulating blood may result from a slow or sudden haemorrhage or from traumatic or operative shock.

The intravenous injection of blood into a patient with a normal heart produces exactly the opposite effect of haemorrhage. The immediate results are increased venous and right atrial pressure, increased ventricular inflow, and increased cardiac output. The increased cardiac output is directly related to the rate of transfusion and the total volume administered.

In the case of a damaged myocardium, sometimes cardiac failure may result from even a very small transfusion. If the blood volume is excessively increased, the left side of the heart becomes dilated and sometimes fails acutely.

If more than a third of the blood volume is lost during an acute haemorrhage, death usually results unless the blood volume is replaced quickly. When haemorrhage is slow, however, the loss of two-thirds of the volume of blood may be withstood because of peripheral vasoconstriction and the pouring of intracellular fluid into the vascular system.

The time to start replacing blood is when the pulse rate first increases. If one waits until the arterial pressure begins to fall, one is confronted with the treatment of hypovolaemic shock, rather than its prevention.

A simple observation which confirms the presence of a reduced blood volume is the poor distension of the veins on the dorsum of the hand, particularly when the hand is allowed to hang downward from the patient's side (5).

In general, a patient in shock with a systolic blood pressure of less than 85 mm. of mercury usually indicates a loss of at least 25 per cent of the blood volume. In the average adult this loss is in the neighbourhood of 1,500 cc. A satisfactory response to transfusion usually raises the arterial systolic pressure 10 to 20 mm. of mercury for each 500 cc. of blood transfused.

Vasopressor drugs may have an undesirable effect when given to support a falling blood pressure in the presence of oligaemia. They, therefore, are not indicated in the treatment of shock consequent to loss of blood volume while waiting for compatible blood. Instead, one of the electrolyte solutions or blood volume expanders should be used (6).

Since the decrease in the blood volume itself, and not the decrease of erythrocytes, is the prime cause of death in such cases, the important point is to re-establish the volume of circulating blood quickly. In this way the patient's life may be saved until compatible blood for transfusion is made available.

To Increase Content of Protein in the Blood

Occasionally it is wrongly assumed that an intake of protein that is adequate for a healthy person is also adequate for a sick person. It is advisable to establish proper values for protein in the circulating blood prior to operative procedures and to maintain them during convalescence. If the amount of protein is inadequate, the tendency to shock is greater, and oedema of the intestines and other tissues may cause disruption of incisions, delayed wound healing, and reduced resistance to infections. It is possible to restore the total amount of protein in the blood of hypoproteinaemic patients by the intravenous administration of sufficient amounts of plasma proteins.

Assuming oral alimentation is impossible, the patient should receive no less than 100 cc. of blood for every pound of weight lost gradually during the two months before operation.

A transfusion of 500 cc. every second day is good treatment. If an emergency operation is impending, give 500 to 1,000 cc. of blood and follow with more blood during the operation (7).

Untoward Reactions

No matter how well a transfusion service supervises the laboratory work and no matter how well the administration of the blood is carried out, a certain calculated risk of an untoward reaction exists. In most institutions a 3 to 5 per cent reaction rate is accepted. In many instances, these untoward reactions may be hard to recognize. Their recognition is particularly difficult if the patient also is under the effects of a general anaesthetic. However, reactions do occur even when the patient is unconscious from a general anaesthetic, and a careful observer should recognize an untoward effect even then.

Untoward reactions are more likely to occur in the presence of certain conditions such as blood dyscrasias or chronic ulcerative colitis, after multiple transfusions or after one transfusion of several bottles of blood. The trend of the times, it seems, is for transfusions to be requested more and more frequently. It is the consensus of many that with this increase of transfusions, the difficulties of finding compatible donors in certain instances and the possibility of untoward reactions may become more and more evident.

At the Mayo Clinic we are conservative in the use of blood transfusions. In certain conditions involving thoracic surgery and cardiac surgery, we are careful not to overload the patients with blood. On the other hand, our experience also has led us to believe that certain surgical procedures such as operations on the hip, extensive dissections in the neck, laryngectomies and various other operations warrant the use of blood transfusions almost routinely as supportive therapy.

Transfusion reactions are of five categories, namely, hyperthermic or pyrogenic, allergic, circulatory, haemolytic, and an undetermined category that includes many bizarre happenings which do not fit into any of the other four categories. In a series of 8,222 transfusions the reaction rate at the clinic was 3.9 per cent.

It is not within the province of this presentation, however, to go into the care and treatment of patients who have had an untoward effect from the transfusions.

Practical Hints Concerning Supportive Measures

Technique of Administration

Physicians often do a very poor or inefficient venipuncture. Unfortunately, little or no instruction in the proper technique of introducing a needle into a vein is given to the intern. Too frequently we encounter advanced graduate students who still have not learned to do this procedure with finesse. As anaesthesiologists it behooves us to stress this particular procedure, because it may mean ability to carry out intravenous supportive therapy without sacrificing a

vein by cutting down to introduce a needle or plastic catheter. Cutting down on multiple veins is seen occasionally. This not only disfigures the patient but also has caused permanent loss of some veins.

In the event of marked peripheral vasoconstriction, shock, or other cause as a result of which the veins are unduly small or collapsed, hot packs applied to the extremities almost invariably will dilate the veins sufficiently to permit easier acces to the lumen.

Another aid is to let the extremity hang in a dependent position to help engorge the veins. After the hot packs are removed, a warmed antiseptic solution should be applied as it will not produce so much vasoconstriction as a cold antiseptic solution will. Anyone having experienced the painful introduction of an 18-gauge or 15-gauge needle will appreciate the use of a cutaneous and subcutaneous injection of an anaesthetic solution before the needle is inserted intravenously.

In the event that it is desired to administer fluids intravenously for several days, a polythene tube may be introduced into the vein by threading the tube through a 15-gauge or 16-gauge needle already inserted in the vein.

The Plastic Needle

A later addition to the armamentarium is the plastic needle devised by Massa and co-workers (8). For most operative procedures it is our practice to insert at least one, and frequently two or three needles, for use during supportive therapy.

Dose and Rate of Administration

For an average adult 500 cc. of blood transfused usually raises the haemoglobin content of circulating blood 10 per cent (1.5 gm. of haemoglobin per 100 cc.) and the erythrocyte count 500,000 per cubic millimeter.

For an average safe rate of administration of blood to an adult, 5 to 10 cc. per minute is adequate. For children the safe amount given per minute is less and varies with body weight. In emergencies, however, it is imperative that unusually large amounts of blood be introduced rapidly.

Care of the Recipient

It is essential that the first 100 cc. of blood in any transfusion be administered slowly to see if any untoward reaction may occur in the recipient. Every transfusion should be supervised throughout its entirety by a competent person. If the patient is seriously ill or has some cardiovascular disturbance, a physician should remain in constant attendance during the entire transfusion.

Vasopressor Drugs

Vasopressor drugs, although not of aid in support of falling blood pressure due to loss of blood, are the drugs of choice to support blood pressure in most instances of circulatory failure associated with normal blood volume. These conditions are myocardial infarction, pulmonary embolism, the "septic shock" of gram-negative bacillaemia, and the loss of vasomotor tone as a result of cerebral damage.

Comment

The judicious parenteral administration of fluids, plasma volume expanders, or whole citrated blood requires the careful attention of the attending physician. The injudicious use of these same fluids may interfere even to a dangerous degree with the physical well-being and convalescence of the patient.

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ANILERIDINE (LERITINE®):[1] A NEW SYNTHETIC ANALGESIC IN ANAESTHESIA

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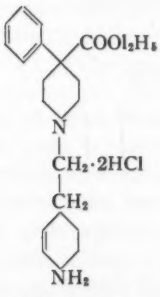
IN SURGERY and anaesthesia it is often necessary to have recourse to opiates for the alleviation of pain. Morphine always remains the drug of choice, but it possesses certain disadvantages, the more important ones being respiratory and circulatory depression, somnolence, nausea and vomiting, constipation, and addiction. These disadvantages explain why there is a continuing search for potent analgesic drugs, the ultimate goal being an ideal compound of a high order of activity and perfectly innocuous. To this end, for several months in the Department of Anaesthesia of Laval Hospital, we have used with great success a new synthetic analgesic named anileridine (ethyl 1-(4-aminophenyl)-4-phenylisonipecotate), available commercially under the trade name of Leritine®.

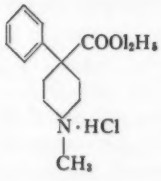
PHARMACOLOGY

Anileridine is a synthetic compound which is a member of the piperidine class of analgesic agents. It differs chemically from meperidine (Demerol®) in that the N-methyl group of meperidine is replaced by N-(p-aminophenethyl). Recent studies, indeed, have demonstrated that phenethyl increases analgesic activity when substituted for methyl on the nitrogen atom, which has been previously considered as the ideal radical.

The pharmacological actions of anileridine have been studied in man (4, 5, 6) and in animals (3), especially in comparison with morphine and meperidine (7, 8).



ANILERIDINE



MEPERIDINE

Pharmacological Action in Animals

In animals anileridine possesses analgesic activity approximating that of morphine but is ten to twelve times more active than meperidine. This pharmacological activity of anileridine is associated with fewer side reactions, and the

[1]Anileridine supplied as Leritine by Merck, Sharp & Dohme, Montreal, P.Q.

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drug is highly effective by the oral route, exhibiting prompt onset of action. The analgesic effect is maximal in 20 to 30 minutes and lasts from 4 to 6 hours. Anileridine like meperidine possesses anticholinergic and antihistaminic properties, and in addition it is effective against experimental cough in animals in contrast with morphine, which exerts little antitussive effect. It does not produce nausea and vomiting nor cause constipation. Its effects on respiration are easily reversible by the narcotic antagonists, such as Nalline® (N-allylnormorphine) or Lorfan® (3-hydroxy-N-allylmorphinane); tolerance to the drug seems to develop more slowly and to a lesser degree than is the case with morphine or meperidine.

We have also experimented with the new drug in dogs in our research facilities at the Centre de Recherches de l'Hôpital Laval. It was employed in premedication in association with atropine in a group of 30 dogs at the dosage of 0.4 mg. per pound of body weight. Its effects, in general, corresponded well with those described above though four of the dogs had nausea and vomiting. It was also administered by the Murphy drip in the same animals following induction of anaesthesia with thiopentone (25 mg./kg. body weight), intubation, and maintenance with oxygen and nitrous oxide. Over a period of 3 hours 125 mg. of anileridine in 250 cc. of 5 per cent dextrose were administered. In the course of this study only a very slight hypotensive effect was noted.

Pharmacological Action in Man

In man, the analgesic property of anileridine bears a close resemblance to that of morphine but is two and a half times more active on a weight basis than meperidine. Anileridine exerts a sedative action mainly, and by itself has little hypnotic effect in comparison with equivalent doses of other narcotics. Respiratory rate was depressed and blood pressure was lowered but for a shorter period of time and to a lesser degree than previously noted in animals. It seems to possess in man spasmolytic and antihistaminic effects with diminution of nausea and vomiting, and absence of constipating effect.

Clinical Investigation

Anileridine was employed in 318 different surgical cases in the preoperative, peroperative, and postoperative periods. In the course of these studies, we shall consider successively, according to the chronological order followed, the effects of the drug in the postoperative, peroperative, and preoperative periods. Our first clinical trials, in fact, were done during the postoperative period when we first employed anileridine alone, then associated with Lorfan. Later, having acquired a better knowledge of the properties of this drug, we used it as a potentiator in the course of anaesthesia. Finally, in the face of the good results obtained, and hoping to verify its efficacy by the oral route, we incorporated it into the premedication regimen.

Postoperatively

Anileridine Alone. We first used anileridine in postoperative analgesia. Our observations deal mainly with the period of recovery when the anaesthesiologist

TABLE I

CLINICAL USE OF ANILERIDINE: NUMBER OF CASES

Type of surgery	Preoperative (I.M. or orally)	Peroperative associated with Lorfan (I.V.)		Postoperative (I.M. or orally)	
		Before induction	After induction	Leritine only	Leritine Lorfan
Pulmonary surgery Lobectomy Segmentectomy Thoracoplasty Pneumonectomy	30	54	26	48	92
Cardiac surgery Mitral commissurotomy Ligature of the arterial canal Pericardectomy				6	4
General surgery Cholecystectomy Spinal fusion Cystoscopy Cystectomy Incision of abscesses Hip arthrodesis, etc.	48	62	18	20	16
TOTAL	78	160		186	

still has the patient under his immediate control. According to our way of thinking, this period extends up to the moment when the patient is perfectly awake, conscious in time and place with regular respiration, with perfect oxygenation, and with blood loss compensated. The dosage used was, in general, less than half the usual recommended dose and ranged from 10 to 25 mg. intramuscularly. The usual dose equivalent to 100 mg. of meperidine is from 40 to 50 mg. The majority of the patients were chest surgery cases, but cardiac and general surgery cases were also included in this study. Age varied from 12 to 61 years.

In all these patients anileridine appeared as a highly effective analgesic, keeping patients calm, fully conscious, and free of unwanted side-effects. Pulse and blood pressure were not affected to any significant degree. The relief of pain produced by these doses on the average was complete and lasted from 40 to 60 minutes. The analgesic action proper seemed to last longer, and did not necessitate a new injection within 2 to 3 hours. Nevertheless, even at the dose of 25 mg., we have found in many patients a certain degree of respiratory depression (up to 10 respirations per minute in one case), and this unwanted effect incited us to use anileridine in conjunction with Lorfan®.

Anileridine Administered Concurrently with Lorfan. Lorfan (3-hydroxy-N-allymorphinane) is related to Levo-Dromoran® (3-hydroxy-N-methylmorphinane) to the same extent that Nalline (N-allylnormorphine) is to morphine. Lorfan and Nalline act in the same way, but it seems that the antagonistic action of Lorfan is superior to that of Nalline (9). The mode of action of the narcotic and antagonist is still a matter of controversy, and it seems that there is a sort of competition between the two for the possession of the sensory and respiratory centres (10). Narcotics have a greater affinity towards the receptors of the

sensory cortex whereas the antagonists possess affinity mainly towards the respiratory centres. The latter, therefore, replaces analgesics inside the respiratory cells and lowers, toward the normal, the sensivity threshold to the stimulus of carbon dioxide. However, this substitution by the antagonist is also directly related to the concentration in the receptors of the sensory cortex, producing along with the diminution of respiratory depression a certain decrease in analgesia. We have, therefore, combined Lorfan with anileridine to ward off the respiratory depression caused by the anileridine used alone. Moreover, this association was made in the proportion of 50 to 1 (i.e., 50 parts Leritine to 1 part Lorfan), in which proportion the antagonist did not seem to oppose the analgesic properties of the narcotic. In all the cases where we employed this combination, no respiratory depression has ever been observed, and the analgesic properties remained as effective as with the use of the narcotic alone.

Peroperatively

Potentialized anaesthesia (11) in our immediate circle is a term in very current usage, considering the very nature of thoracic surgery. By this term is meant a technique whereby, owing to the use of certain pharmacological agents, the organism is placed in such a state that it is possible to maintain anaesthesia at the same time superficial but effective with the use of minimal doses of the usual anaesthetics (thiopentone, nitrous oxide). Thus, with the use of this technique, it is possible to keep the patient perfectly oxygenated and without major neurovegetative or vasomotor reactions, throughout the course of the surgical intervention. It permits us also in the immediate postoperative period to obtain with rapid if not immediate awakening, a conscious patient able to expectorate and not depressed from the respiratory point of view, and also able to react to minimal painful stimuli. The clinical investigation of the anileridine Lorfan combination in the postoperative period having produced very satisfactory results, we then used it during the peroperative period as potentiator. The intravenous route alone was utilized, and the doses of anileridine used ranged from 0.3 to 0.4 mg./kg. body weight. The age of the patients varied from 12 to 57 years.

Technique

Premedication as usual comprised the administration of a non-barbiturate hypnotic (Noludar®) and of a phenothiazine derivative (Phenergan®) on the evening before surgery. In the morning, 1½ hours before surgery, a phenothiazine derivative was administered followed a half-hour later by a narcotic and a vagolytic agent. The doses of these drugs were determined on the basis of age, body weight, and tolerance of the individual. Induction was effected by the use of a barbiturate (thiopentone) and of a relaxing drug of short action (succinylcholine) to permit intubation and aspiration bronchoscopy if necessary in the very beginning. Maintenance was effected by means of oxygen, nitrous oxide, and by the azeotropic mixture of Fluothane and ether (12) and a relaxant of short action administered by the Murphy drip. In certain cases, the anileridine-Lorfan combination was employed prior to induction. The injection was done

about 10 minutes prior to the use of the barbiturate, the dose of the latter being decreased by half. In other cases it was administered after induction during the period of maintenance while the degree of anaesthesia was still superficial. It should be noted that "anileridine" does not mix with thiopentone (flocculation) because of pH difference.

Results

The combination anileridine-Lorfan has enabled us to use superficial anaesthesia, in thoracic surgery mainly, without undesirable side-effects. During anaesthesia the restricted use of barbiturates, especially in patients with hepatic insufficiency, the reduced quantity of relaxants, and the absence of respiratory and circulatory depression have asserted themselves as very important advantages. Moreover, while obtaining highly effective anaesthesia with the minimum of toxic effects, this potentialized anaesthesia adds considerably to safety, especially in being non-inflammable and allowing the use of electrocautery.

The obvious action of the anileridine-Lorfan combination by the intravenous route is observed simultaneously 2 to 5 minutes after the injection and is generally of 25 to 40 minutes duration. This explains why we did not meet with respiratory depressions in the beginning such as were obtained with the Nisentil-Lorfan combination, because of the more rapid action of Nisentil. Awakening is calm and prompt. The patient becomes rapidly conscious, answers to questions, and all his reflexes have returned to normal after a few minutes. At this state it seems that anileridine possesses somewhat prolonged analgesic activity extending even throughout the immediate postoperative period, that is to say during the first two hours. As a matter of fact, during this period, except in rare cases, no narcotics have been administered in this series to patients who have received the anileridine-Lorfan combination during anaesthesia. In the doses used no nausea or vomiting were encountered.

Preoperative Treatment

Finally, anileridine was used as premedication in the average dose of 25 mg. by intramuscular injection. However, the oral route was also used and anileridine proved to be highly effective by this route. Its effects as premedication are in general comparable to those of meperidine. One must, however, always associate with it the drying effects of atropine.

Conclusion

Anileridine (Leritine®) a new synthetic analgesic offers certain advantages over other opiates. Possessing analgesic activity comparable to that of morphine, it soothes the patient but keeps him conscious without precipitating him into profound sleep. The respiratory and circulatory depression in the usual doses is minimal. Owing to its anticholinergic and antihistaminic activity, nausea and vomiting are only rarely seen. Moreover, this new analgesic agent is highly effective orally and seems to have brought about no constipating effects up to the present stage of investigation. These advantages certainly are very valuable

and anileridine will become a very important tool in the therapeutic armamentarium against pain. Nevertheless, one should not be led to believe that it will eventually replace morphine entirely.

Summary

Anileridine (Leritine®) is a new synthetic analgesic drug and is a member of the piperidine class of analgesic agents. It differs from meperidine (Demerol) in that the N-methyl group of meperidine is replaced by an N-aminophenethyl group, which increase its analgesic activity.

In this study, we have discussed the efficacy of the new drug in the periods immediate to anaesthesia, which are, chronologically, the postoperative, the peroperative and the preoperative periods.

In the postoperative period, even at half the usual dosage, it proved itself to be a potent analgesic with few undesirable secondary effects. Nausea and vomiting are rare. The patient is without pain and remains conscious without hypnosis. When associated with Lorfan, higher dosage may be used without respiratory depression.

In the peroperative period, a light and highly effective potentialized anaesthesia has been possible with the association anileridine-Lorfan with minimum respiratory and circulatory depression. A calm, painless, and prompt awakening is observed. The patient is without pain, because the analgesic action of anileridine (Leritine) seems to extend over a period of 2 to 3 hours. In the preoperative period, anileridine by mouth was found very effective. Its effects as a whole are similar to those of meperidine. We must, however, associate with it the drying effect of atropine.

Anileridine has proven to be a very advantageous new narcotic and will certainly deserve high consideration.

Résumé

L'aniléridine (Léritine) est un nouvel analgésique synthétique de la famille de la pipéridine. Un groupement N-(p-aminophénétyl) au lieu du groupement N-méthyl le différentie de la mépéridine (Démérol) et en augmente la puissance analgésique.

Dans ce travail, nous avons voulu exposer les résultats efficaces obtenus avec le Léritine dans les périodes immédiates de l'anesthésie, à savoir, selon l'ordre chronologique suivi, post-opératoirement, per-opératoirement et pré-opératoirement.

Dans la période post-opératoire, il s'est montré, même à un dosage réduit de moitié, un analgésique puissant sans effet indésirable important. Les nausées et vomissements apparaissent rarement et le patient est calme et conscient sans être plongé dans un sommeil profond. Son association avec le Lorfan empêche la dépression respiratoire que peuvent causer les doses plus élevées.

Durant la période per-opératoire, l'association Léritine-Lorfan a favorisé l'emploi d'une anesthésie potentialisée légère et hautement efficace avec le

minimum de dépression respiratoire et circulatoire. Elle a aussi favorisé un réveil prompt et calme avec le minimim de douleur, car le "Léritine" semble posséder une puissance analgésique assez prolongée s'étendant sur une période de 2 à 3 heures.

En prémédication, l'aniléridine (Léritine) a donné d'heureux résultats par la voie orale, ses effets se comparant à ceux de la mépéridine (Démérol). Toutefois, il faut lui associer les effets asséchants de l'atropine.

Avec tous ces avantages, l'aniléridine (Léritine) sera un atout précieux dans l'arsenal thérapeutique.

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BLOCK OF THE BRACHIAL PLEXUS BY THE AXILLARY ROUTE[1]

FERNANDO HUDON, M.D., F.R.C.P.(C), F.F.A.R.C.S., and
ANDRÉ JACQUES, M.D., F.R.C.P.(C).[2]

A TECHNIQUE for blocking the brachial plexus by the axillary route was described by Labat in 1922 (1) and in Pitkin's *Conduction Anesthesia* in 1946 (2); but the method advocated by Arcado and Adriani in 1949 was simpler and more effective (3). However, it took nine years before we heard of the application of this technique with some success. In the Current Comment of *Anesthesiology* of March–April and of September–October, 1958, Preston J. Burnham and Kenneth F. Eather report and discuss the successful use of this method of regional anaesthesia (4, 5). In January and February, 1959, articles by Clayton, Turner, and Burnham treating upon this procedure were published in the *Journal of the American Medical Association* (6, 7).

Having had 17 years' experience with the brachial plexus block by the supraclavicular route, we became interested in this type of block by the axillary route.

TECHNIQUE

The patient lies with his arm abducted at 90 degrees in a neutral position or in external rotation. To keep the arm in a neutral position, an assistant holds the limb at the wrist; if the arm is placed in external rotation, the hand and forearm rest on a pillow near the head. The operator stands inside the arm. He must feel the axillary artery; but, in order to locate it, he must be familiar with the anatomical relations of the block in the axilla. The landmarks must be carefully

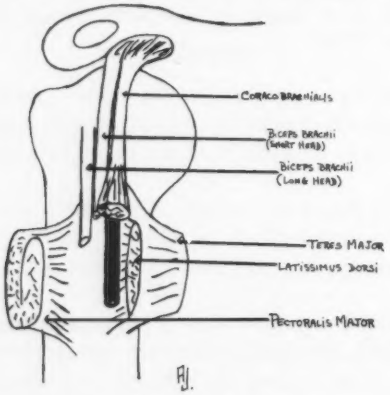

FIGURE 1

[1]Nesacaine hydrochloride used in this study was supplied by Maltbie Laboratories Division, Wallace & Tiernan Ltd., 925 Warden Ave., Scarborough, Ont.

[2]Department of Anaesthesia, Hôtel-Dieu Hospital, Quebec City, P.Q.

located. At the level of the insertions of the pectoralis major muscle anteriorly and of the conjoint tendons of the latissimus dorsi of the teres major muscles posteriorly, the neurovascular bundle can be felt.

In Figure 1, one can see that, between the insertions of the pectoralis major muscle and of the latissimus dorsi muscle, there is, along the axillary artery, the tendon of the long head of the biceps muscle and of the coracobiceps muscle.

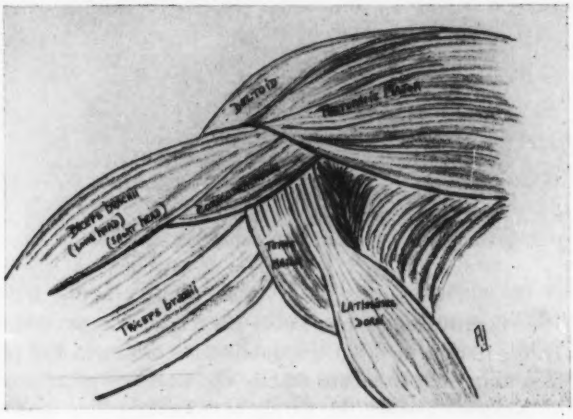

FIGURE 2

In Figure 2, one can see the same muscles from another plane and the importance of the coracobrachialis muscle as a landmark is apparent. An imaginary line can be drawn perpendicular to the insertions of the pectoralis major muscle anteriorly and of the joint tendons of the latissimus dorsi and of the teres major muscles posteriorly, because the injection must be made through this line anterior and posterior to the axillary artery.

A very important landmark is the conjoint tendon of the coracobrachialis muscle and of the short head of the biceps muscle beneath the inner side of the pectoralis major muscle near its insertion at the humerus. The fingertip palpates the coracobrachialis muscle below the pectoralis major muscle and, posteriorly, it feels the neurovascular bundle where the terminal portion of the axillary artery lies. Posterior to this bundle, the finger feels the anterior part of the tendon of the latissimus dorsi muscle.

By pressure, the finger feels the pulsations of the axillary artery in the groove beneath the coracobrachialis muscle where the space of the neurovascular bundle is located. The space, 3 cm. in diameter, is surrounded by a fascia which is the prolongation of the axillary fascia.

In Figure 3, a sagittal section shows the median nerve which is medial and more superficial than the axillary artery; the musculocutaneus nerve which is anterior and beyond the axillary artery; the ulnar nerve which is inferior and below; the radial nerve which is posterior, below and behind the axillary artery; the medial brachial cutaneus and the medial ante-brachial cutaneus nerves which are inferior and superficial to the axillary artery.

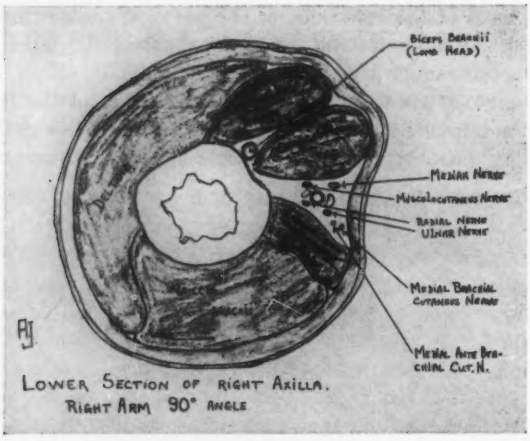

FIGURE 3

Anterior to the neurovascular bundle is the coracobiceps muscle, and posteriorly there is less than ½ in. from the cutaneous surface to the medial side of the humerus. It is important to locate exactly the terminal portion of the axillary artery to avoid injection ouside the fascia surrounding the space or into the muscles.

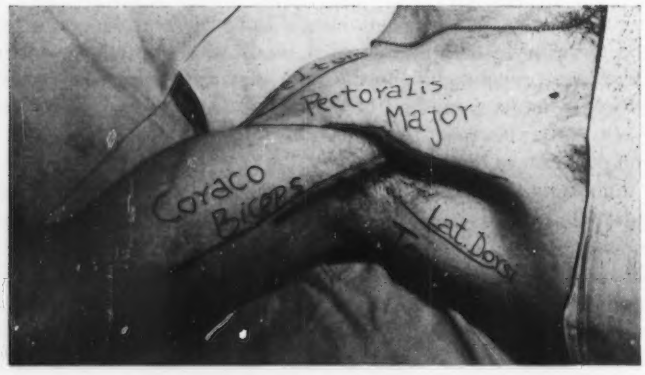

FIGURE 4

In Figure 4, one can see the projection of the muscles on the skin, the projection of the axillary artery, and the site of the intradermal wheal.

In Figure 5, the finger feels the pulsation of the axillary artery in the space of the neurovascular bundle. The finger also feels the coracobrachialis muscle anteriorly and the tendon of the latissimus dorsi muscle posteriorly. In this way, we are certain of the exact location of the axillary artery and we can place a finger right in front of it: the method is indeed a simple peri-arterial infiltration in the axilla with a No. 24 needle, 2.5 cm. long.

FIGURE 5

An intradermal wheal must be raised below the coracobiceps muscle, 2 cm. higher than the insertion of the pectoralis major muscle and just in front of the axillary artery. The injection is made just underneath the fascia because the median nerve is more superficial than the axillary artery; the injection is also made on each side of the axillary artery by reinserting the needle through the same cutaneous wheal.

Each time, the skin is retracted slightly on each side, and the needle is directed at an angle of 30 degrees to the skin, before penetrating the fascia. When the needle is in the right place, strong oscillations of its hub are noticed. It is important to observe the movements of the needle oscillating with the pulsations of the axillary artery. If the oscillations of the needle are weak or absent, it is probable that the needle has penetrated anteriorly or posteriorly into an aponeurosis or into a muscle. Pulling the needle out slightly is often sufficient to see it pulsating again. The withdrawal of the needle out of an aponeurosis gives a particular sensation of escape.

To demonstrate a more precise location of the axillary artery, a two-needle technique is suggested. At the level of the inferior border of the pectoralis major muscle near the humerus, the axillary artery is sought with the finger just beneath the coracobiceps muscle. When the finger of the free hand feels the axillary artery, a first needle is introduced at a 30 degree angle, slightly anterior to the axillary artery, through the skin, the fat, and the fascia. After the fascia has been pierced, the pulsations of the needle are noted. Another needle is introduced on the opposite side at a 30 degree angle with the skin, close to the axillary artery and at the same level. In this manner, mistakes such as the puncture of a muscular aponeurosis, or the insertion of the two needles on the same side of the axillary artery, are avoided.

In Figure 6, one can see the exact location of the two needles. An injection of 10 cc. of Xylocaine hydrochloride 2 per cent or of Nesacaine hydrochloride 2 per cent with epinephrine 1/150,000 dilution is made through each needle, on both sides of the axillary artery and in front of the axillary artery at the withdrawal

FIGURE 6

of the needle. Aspiration tests and control of the oscillations are done before and after each injection.

The advantages of this technique are:
Landmarks located easily
Less apprehension, less objection from the patient
No pain inflicted during the injection
No necessity to elicit paraesthesia
Drug toxicity decreased by half
No problem with haematoma
Anaesthesia more suitable about the elbow
Bilateral brachial block permissible
Shoulder girdle not involved by anaesthesia
Elongation of the brachial plexus and neuritis less probable

The disadvantage is that the axillary route cannot be used for a dislocation of the shoulder joint or for a closed reduction of a fracture of the clavicle.

DISCUSSION

The block of the brachial plexus by the axillary route was performed at our hospital for the past year. It was learned and managed by 13 anaesthetists not familiar with this technique. It was administered for interventions about the elbow, the forearm, and the hand. A brachial plexus block by the axillary route may be used also for treating painful vasospastic conditions in which the upper limb is involved.

Since April, 1958, 165 axillary blocks have been performed for surgical procedures of the upper limb. Therapeutic axillary brachial blocks are not included in this series.

Analgesia was complete in 142 of these 165 blocks; in 23 blocks, analgesia did not develop as expected and had to be completed by local infiltration or by general anaesthesia.

Failures, amounting to 14 per cent, appeared mostly at the beginning of this series and were due to imperfect technical knowledge. Failures with the axillary brachial block seem to be nothing but a lack of mastery of the technique: too low, too deep, too high infiltration; too weak solution; injection into the neighbouring muscles.

In the last four months, 105 axillary blocks were done, with incomplete analgesia in only seven, giving 94 per cent of successful results.

During the same period of time, 81 brachial blocks have been performed by the supraclavicular route: complete analgesia developed in 77, giving 95 per cent good results in comparison to 86 per cent for the total number of 165 axillary blocks.

A 16 mm. colour film on the axillary block, produced by Drs. A. Gagné and H. Drolet, residents in the Department of Anesthesia of Hôtel Dieu de Québec, was shown along with the paper at the meeting.

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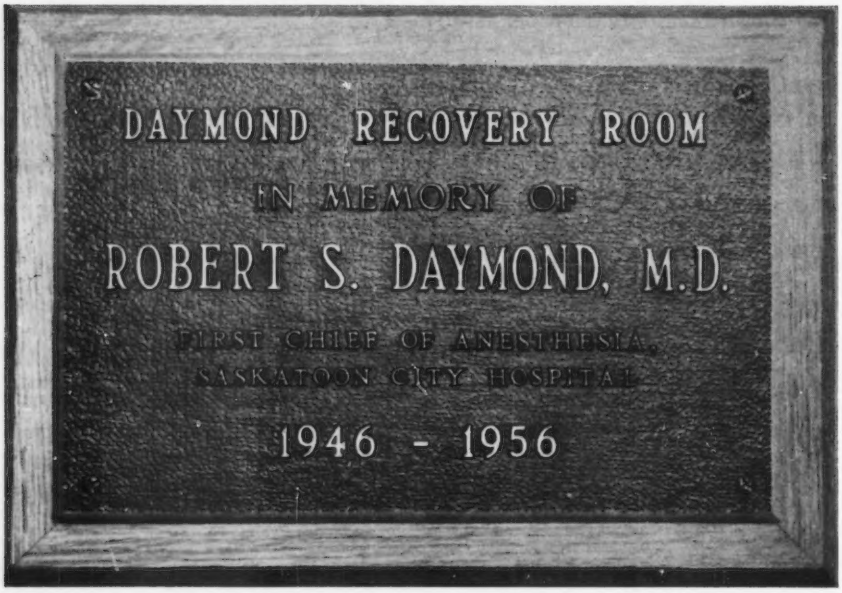
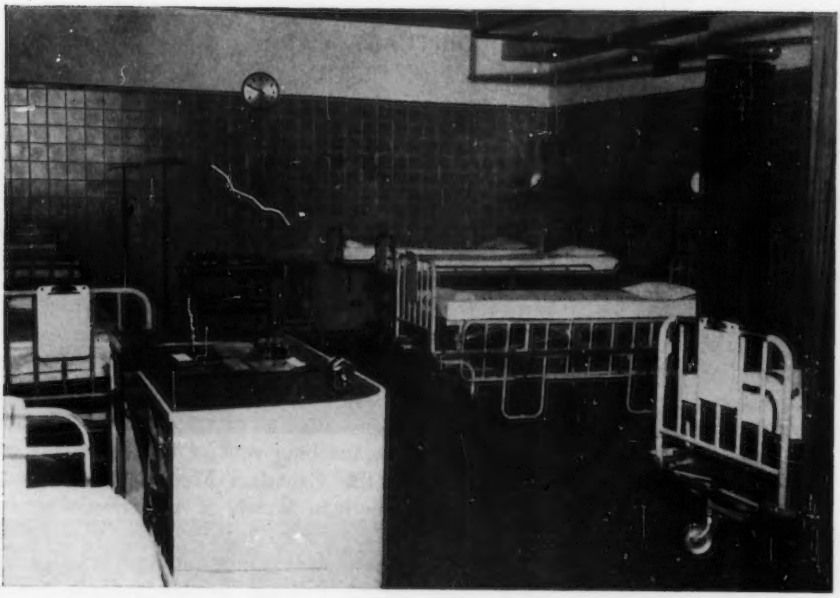
THE DAYMOND RECOVERY ROOM, SASKATOON CITY HOSPITAL

THE MEDICAL STAFF of the Saskatoon City Hospital have given a plaque in memory of the late Dr. Robert S. Daymond, which has been placed at the entrance to the recovery room and which designates it *The Daymond Recovery Room.* To commemorate Dr. Daymond's many contributions to the hospital as its first Chief of Anaesthesia and first full-time anaesthetist, a service was arranged at which Mr. L. T. Muirhead, Superintendent of the Hospital, unveiled the plaque, which had been especially chosen in recognition of Dr. Daymond's keen interest in the recovery room and the time and care he devoted to its planning.



Dr. J. M. Campbell spoke of Bob's association in many long and difficult hours in the operating room—his calm and careful attitude to his work and his kindness to the patients whom he served. Dr. M. V. Morton praised the quality and thoroughness of the planning for the recovery room in which Dr. Daymond had had such an important part and observed that the whole operating room staff would be reminded of the constant devotion that he had shown to all aspects of his work as an anaesthetist.

The Medical Staff were grateful for the presence at the service of Mrs. Daymond and the children, as well as many of Bob's friends and colleagues. The Rev. G. E. Speers, Chairman of the Saskatoon Ministerial Association, opened the service and read the benediction.



OBITUARY

Dr. Angus Alexander MacMillan, 1915–1959

The death of Dr. Angus Alexander MacMillan occurred in Vancouver, on Tuesday, June 23, 1959. Dr. MacMillan was born in Guelph, Ontario, and was a graduate of Queen's University, 1941. Following internship at the Ottawa Civic Hospital, Dr. MacMillan served in the R.C.N.(R) from 1942 to 1946. He began his postgraduate training in anaesthesia at the Royal Victoria Hospital, Montreal, and completed his training at the Vancouver General Hospital, receiving his certification from the Royal College of Physicians and Surgeons in 1950.

Dr. MacMillan was a senior partner of Associated Anaesthetic Services, Vancouver and a member of the Attending Staff of the Vancouver General Hospital, the Vancouver Children's Hospital, and the teaching staff of the University of British Columbia. He was a member of the Canadian Medical Association, Canadian Anaesthetists' Society, and the American Society of Anaesthesiology.

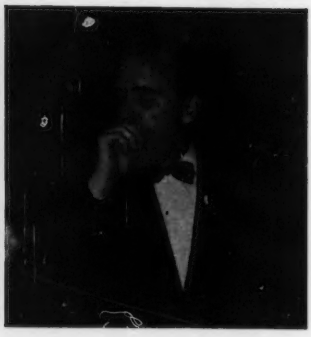
"Gus," as he was affectionately called by his associates, was a devoted family man, and a strong, dedicated supporter of the United Church of Canada.

The Canadian Anaesthetists' Society has lost a valued member. Those of us who were associated with him in partnership have lost a capable, trusted, and sincere friend and partner.

To his widow, Laura, daughter Marian, and son Bruce, the members of the Canadian Anaesthetists' Society extend their deepest regrets.

H. B. G.

PERSONALITIES FROM THE CANADIAN ANAESTHETISTS' SOCIETY
ANNUAL MEETING, 1959



PERSONALITIES FROM THE CANADIAN ANAESTHETISTS' SOCIETY
ANNUAL MEETING, 1959

EXHIBITORS' REPRESENTATIVES
CANADIAN ANAESTHETISTS' SOCIETY ANNUAL MEETING, 1959

BOOK REVIEWS

A MANUAL OF ANAESTHETIC TECHNIQUES. By Wm. J. Pryor. Bristol: John Wright and Sons Limited [Toronto: The Macmillan Company of Canada]. Pp. 224. $4.70.

As stated by the author, this manual is written primarily for house-surgeons and registrars. It contains much useful information on apparatus, equipment, and techniques of administration which the part-time anaesthetist will find of considerable help, but it is all found in larger textbooks.

All apparatus described including automatic ventilators with the exception of the Heidbrink is English and no references later than 1954 are given.

In keeping with the title, physiology and pharmacology are given little space. A six-page chapter is devoted to the mechanical and physiological aspects of anaesthesia, as applied to gas machines and oxygen and carbon dioxide, and there is a section on the physiological aspects of spinal anaesthesia. The chapter on local anaesthesia deals with a few of the nerves of the face, neck and upper extremities, paravertebral and caudal blocks, but omits epidural and blocks of the lower extremities. No mention is made of defibrillation by electroshock in primary cardiac failure in the chapter dealing with anaesthetic emergencies and difficulties, and although cardiac massage is advised within two minutes of stoppage, no directions are given as to how effective massage should be carried out.

Nevertheless there is much useful information in this manual.

S. M. Campbell, M.B.

INSTRUMENTATION IN ANESTHESIOLOGY. By W. H. L. Dornette and V. L. Brechner. Philadelphia: Lea and Febiger [Toronto: The Macmillan Company of Canada]. 1959. $8.00.

The continually widening recognition of the anaesthetist as an applied basic scientist rather than as a technician has been underlined by the great need for reliable information as to the patient's status during surgery. In fact, many of the most major surgical procedures are only a practical proposition if various physiological parameters can be monitored satisfactorily. Consequently, there has been a marriage between the investigator, with his instrumental armamentarium, and the clinician with his daily requirements—both during surgery and in post-graduate teaching.

For some years now, there has been a need for a book which would offer help to those not well grounded in medical electronics and to those who are inexperienced in the use of monitoring devices; the volume under review makes a most creditable attempt at fulfilling the current need. It is written on the assumption that the reader's knowledge is minimal and it contains a wealth of information. However, it does not fill the role of a "do-it-yourself" manual—falling far short of this in many chapters (the section on blood gas analysis being one exception). Rather does it give an example of each type of apparatus and describe the principles on which it works.

The authors have decided not to enumerate and compare the various makes of equipment available for the performance of each monitoring task, electing to describe one of each—and selecting a piece of equipment with which they have personal experience. This has produced the paradox, in some instances, that some of the most popular makes on the market are not mentioned—multi-channel recorders and oximeters being cases in point. Those of us who are repeatedly faced with the difficult task of deciding what make of equipment to purchase may feel that the pros and cons of different types could have been more fully discussed, without directly embarrassing specific manufacturers.

The reviewer felt that the chapter on electrocardiography gained little by the addition of an abbreviated discussion on interpretation and would like to see this space utilized to provide more information on integration, digital display, the use of tissue electrodes, the errors imposed on volumetric blood gas analysis by anaesthetic agents, and—remarkable for its absence—pH determination.

The index is adequate but, in view of the authors' decision "to minimize the amount of material presented," a considerably more expanded bibliography might be valuable, with particular reference to practical applications.

Despite these minor criticisms, inevitable in the first edition of a book on such a subject, this volume can be highly recommended to anyone seriously interested in the specialty of anaesthesia. The first few chapters, on safety precautions, basic physics, electrical interference and amplifiers, being particular highlights in a most interesting and welcome addition to one's library.

H. B. F.

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THE CANADIAN ANAESTHETISTS' SOCIETY JOURNAL

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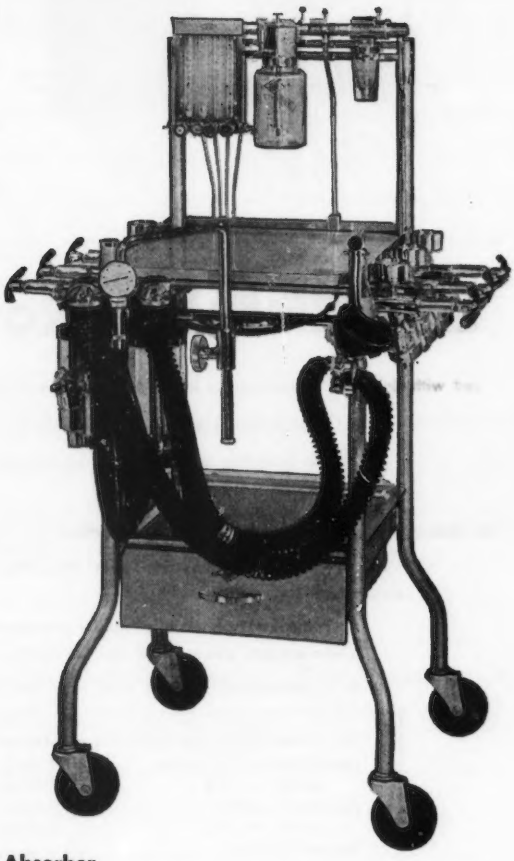

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SCIENTIFIC PROGRAMME

The Scientific programme, divided into plenary and concurrent sessions, will extend from Monday, September 5th, to Friday, September 9th, 1960.

The Programme Committee invites contributions to the scientific programme in the form of reports on current clinical investigation, basic research, teaching of anaesthesia and organization of departments.

The Committee is anxious to receive papers from all countries, but it is necessary to strictly limit presentations for the plenary sessions to twenty minutes including presentation of slides or brief illustrative movies, and to ten minutes for the concurrent sessions.

Discussion of the twenty-minute papers will be limited to two five-minute periods by designated speakers and there will be no discussion of the ten-minute presentations.

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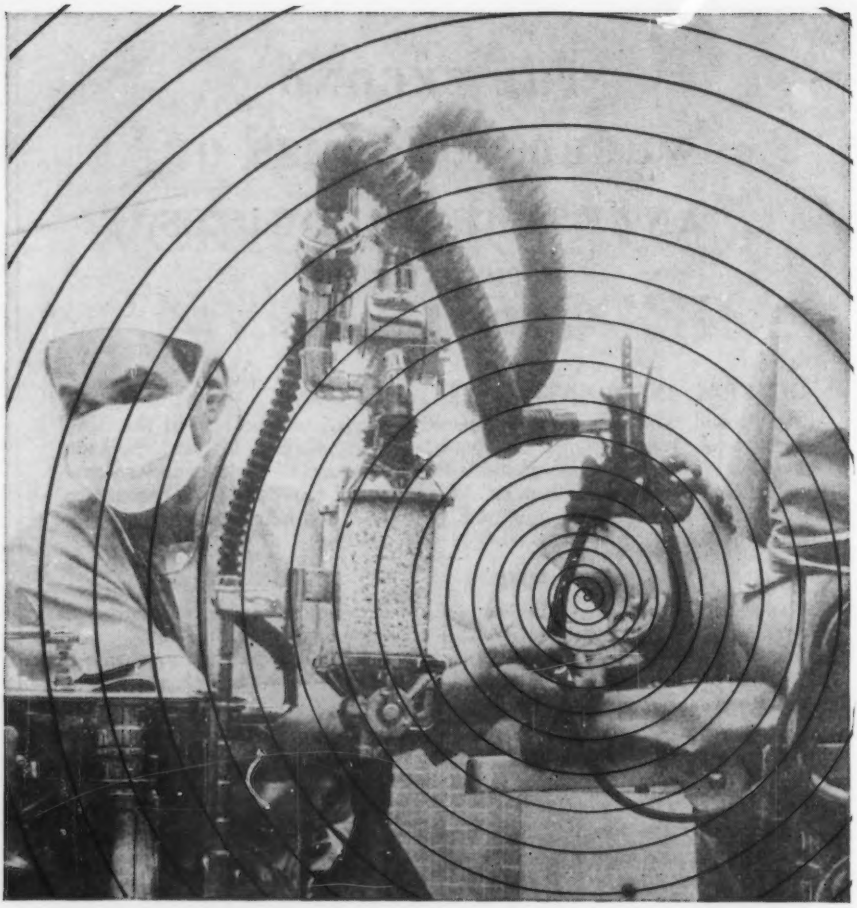

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Manuscripts

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4. Griffith, H. R. & Johnston, G. E. The Use of Curare in General Anaesthesia. Anesthesiology 3: 481 (1942).

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